A GEOGRAPHY OF MAN

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with the collaboration of

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No man can reveal to you aught but that which already lies half asleep
in the dawning of your knowledge.
For the vision of one man lends not its wings to another man.

And even as each one of you stands alone in God's knowledge,
so must each one of you be alone in his knowledge
of God and in his understanding of the earth.

KAHLIL GIBRAN

PREFACE

Geographers observe and catalogue the facts of area differentiation on the earth, and analyze the significance of these facts. They attempt to discover what it is that makes one area differ from another, or in what respect differing areas have certain aspects in common. The facts which combine to produce differences from place to place are of many diverse kinds, including those which result from physical processes, operating in obedience to the precisely formulated laws of physics, chemistry, or biology, and those which result from cultural processes, operating under the much less precise principles of the social sciences. Geographers must deal with these varied phenomena in so far as they lead to area differentiation on the earth.

But geographers do much more than observe and catalogue. They also analyze the significance of differences which are observed from place to place. To discover the significance, or meaning, of a fact of area differentiation requires inquiry into both causes and consequences. The present nature and arrangement of things on the earth have meaning with respect to the operation of physical or cultural processes in the past. To understand the significance of what is observed on the earth today it is necessary to go back to origins and trace developments. But it is also necessary to forecast the consequences. Only when the present nature and arrangement of things on the earth have been projected both into the past and into the future, has the significance of the differences from place to place on the earth been fully analyzed.

One of the basic factors in area differentiation is the distribution and density of population. It is this aspect of geography which forms the core of this book. A geographer is not interested in population density as a statistical fact to be analyzed by statistical methods. He must see the pattern of population on the earth in its area relations, that is, in its relative position with respect to other differentiating features of the earth. In this book the facts of population density are

shown on Plates 1–6, beginning on page 583. Plates 9–20 show the patterns of natural vegetation and surface configuration—two aspects of the physical land which, together, outline the major lineaments of the face of the earth. These patterns are drawn on the same outline maps as those used for the population density, so that by a comparison of the corresponding maps the major area relationships of man on the earth can be identified. These and the other plates make it possible to see the pattern of mankind in relation to certain physical and cultural elements of the total environment which are assumed to be relevant.

This is the beginning of geographic study. At once the problem is raised: what is the significance of the differences of population density which are observed from place to place on the earth? The answer involves an evaluation of the various processes which have led to the present arrangement of people on the earth; and it also involves a forecast of the consequences of this present arrangement with respect to the economic, social, political, or strategic situations which we face.

The analysis of the significance of human distribution on the earth involves certain concepts of a theoretical nature. These concepts are, in fact, generalizations regarding man's relation to the land. The theoretical concepts which guide a field of study must never be accepted as beyond challenge—they must be subjected again and again to critical examination as they are confronted with new data. Yet as long as they survive such challenge, the concepts themselves must inevitably affect the kind of data that are gathered. There can be no such thing as a complete description of the content of an area. The facts which are selected as relevant are identified in terms of the theoretical concepts. For example, for many years geographers have observed what they called "human responses" to specific physical conditions, guided by the theoretical concept that man's activities were in large measure determined by the relatively unchanging facts of the physical earth. This concept now seems inadequate and inaccurate, since it can be shown quite clearly that the significance of any physical feature of the earth is different for different groups of people; that the meaning of the physical environment so far as man is concerned is determined not by the inherent character of the environment, but by the importance attached to the environment by man.

In this book there are five basic concepts regarding man's relation to the land. These concepts are elaborated and illustrated throughout the book, but may be stated in brief form as follows:

1. That the significance to man of the physical features of the land is determined by the culture, or way of living, of the people; and therefore any change in the attitudes, objectives, or technical abilities of a people inhabiting an area reouires a re-evaluation of the significance of the land.

2. That an exception to this first generalization occurs when the character of the physical earth itself changes rapidly in the presence of a particular group of inhabitants—as when there are volcanic eruptions, when harbors silt up, when rivers change their courses, or when there are actual changes of climate; and that in such circumstances the land exerts a positive influence on man.

3. That there is one basic necessity in man-land relations—that any human society, if it is to survive, must form a workable connection with the resources of the land.

4. That the simple cultures, in which the ways of making a living are few, form a few simple, direct connections with the land in base areas which are closely restricted, and that the more complex is the culture (that is, the greater is the number of ways of making a living), the greater is the variety of possible connections with the land, the less direct those connections are, and the larger is the base area.

5. That the industrial society is vastly more complex than any previous society, and its base area cannot be less than the whole globe; and that its survival therefore depends on the achievement of some measure of world unity.

A Geography of Man is written for a variety of uses. Without reference to the extensive bibliography given in Appendix F, and with or without reference to the other appendixes, it can be used as a text for elementary college courses in geography. In this way it makes a con-

tribution to general education, for the materials in the main part of the text make as little use as possible of specialized concepts or techniques. The subject matter of the main text is fundamental to the other social sciences: it constitutes one formulation of the kind of knowledge of world geography which should be at the command of every educated man and woman.

More definitely specialized material is placed in the appendixes. Appendix A, by Hibberd V. B. Kline, Jr., presents a general, elementary picture of the nature and use of maps. Appendixes B, C, and D give in outline form highly condensed statements setting forth the principal facts and processes of climatology, geomorphology, and hydrography. By making use of the references listed at the end of each of these appendixes, the material in this book can be amplified to provide a much fuller coverage than is possible here. For more advanced students, whether in the other social sciences or in geography, the text provides a new statement of the principles of geography and a study in the method of geographic expository writing and analysis. With the references included in Appendix F, it provides the kind of general outline desirable for defining a student's grasp of world geography at the pre-doctoral level. For professional geographers and others it offers an up-to-date formulation of the concepts and methods of geography.

A Geography of Man makes use of numerous passages from the author's *An Outline of Geography* (Ginn and Company, Boston, 1935), but the present book uses these passages in quite different context from that in the earlier work. Whereas *An Outline of Geography* had as its major objective an understanding of the landscape patterns of the earth, the present book is intended to offer an analysis of the significance of the differences in population density on the earth. In both books the same outline, consisting of eight groups of natural regions, is used—based on the conditions of surface and natural vegetation. These groups are used because they have proved to offer a satisfactory framework for the portrayal of the world's major natural features—features in relation to which man's pattern of distribution is to be described.

P. E. J.

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A GEOGRAPHY OF MAN

INTRODUCTION

MAN ON THE EARTH

Most parts of the earth's surface are empty of human inhabitants. Vast areas are only very thinly peopled, with small communities separated by many miles of empty land. In southeastern Asia, on the other hand, about half of all the people in the world are crowded into less than a tenth of the world's habitable area. In Europe a little less than a fifth of mankind is occupying an area which amounts to less than one twentieth of the habitable world.

Yet to draw the conclusion that a great movement to the empty lands of the world is about to take place would be quite wrong. People are concentrated in certain parts of the world because these parts offer greater opportunities for the support of human life than other places. These opportunities are in part the result of the resources of the earth itself, and in part they are man-made. But the tendency today, as always, is for people to move from areas of lesser to areas of greater economic opportunity. The population in areas of concentrated settlement is becoming more concentrated; the population of thinly peopled areas is becoming thinner.

The fact of uneven population distribution is basic to the study of human societies and human institutions. Population density and arrangement are involved directly or indirectly in every economic, social, political, or strategic problem. Underlying all the great domestic and international issues of our time are the facts of man's relation to the earth. In every occupied square mile of the earth's surface man encounters a unique set of physical conditions, and, in order to survive, he must establish some workable connection between the human society and the resources of the earth. Man is intimately bound to the earth: from it he derives all the materials for his food, clothing, and shelter; from earth materials he fashions the tools which give him economic power and the weapons which give him military power. Man's civilizations have always been, and always will be, constructed on the foundations of a particular set of relations to the land. As John Dewey has written: "Human nature exists and operates in an environ-

ment. And it is not 'in' that environment as coins are in a box, but as a plant is in the sunlight and soil."

The influence of the natural environment on human life is chiefly one of limitation and hindrance. The stimulus to such action as will overcome obstacles or take advantage of opportunities is provided by man himself. Man alone, among all the forms of life on the earth, possesses the capacity to raise his head and look about him, to observe his surroundings and himself, to simplify the confused complexity of the things he sees by arranging and classifying them, to imagine explanations, and to make use of his knowledge, little as it may be, in altering and transforming at least the more plastic parts of his habitat. Yet most of the basic conditions of life are beyond his control: he is still a product of the earth and dependent on it.

Nature itself is quite indifferent to human aspirations. A land is neither friendly nor unfriendly, except as man has always personified the natural forces about him and given them human attributes. Repeatedly history offers examples of the changing habitability of specific regions. The same countries which to one people seem to be inhospitable and lacking in resources, to another people may seem to offer great advantages for the development of human society; and the same countries which once provided support for a flourishing civilization, may now appear as difficult places in which to make a living. What is the difference? In some cases, perhaps, there have been climatic changes, or shifts in the courses of rivers, or other natural phenomena that do actually change the physical character of the land; but in many other instances there is no evidence of such change. The difference is in the human group. For a people without steel plows, railroads, or great urban markets, the world's grasslands, for example, were rated as lands of low productivity; but for a people armed with the mechanical equipment and possessing the economic institutions of the industrial era, these same lands became major sources of wheat and meat. The story does not always run in the direction of progress, however. There are many regions in which a human society, armed with primitive tools, was once able to form a workable connection with the resources of the land, but in which men with machines have been unable to survive because of the rapid destruction of the resources. What degree of slope

is too steep for agriculture? The answer to this question depends on the technique of farming, for slopes which can be cultivated with the hoe may be much too steep for farmers with plows.

In other words, the significance of the physical conditions of the land depends on the attitudes, objectives, and technical abilities of the inhabitants.

These attitudes, objectives, and technical abilities of a people are traits which form a part of the traditional way of living. In the long course of human history various human groups have appeared, each having its own peculiar set of beliefs, its own institutions, its customs, its familiar foods, its consecrated system of moral values. The tendency is strong to resist change. The aggregate of all these customary forms of thought and action which characterize a people is what the anthropologists describe as a *culture.*

Stages of Culture Development

Differences of culture are easily recognized. There are certain cultures, some of which survive to the present, which can be described as simple because the traditional ways of making a living are few. Others, notably our own, are complex because there are many ways of making a living. In general, the more complex the culture, the greater the density of population that can be supported.

Although it is obvious that man's cultures have changed over the ages from the simple toward the more complex, there is disagreement among social scientists regarding the nature of this change. Has there been a more or less steady evolution within each culture? Some writers believe that such evolution is a useful generalization of man's progress. Others, however, believe that the outstanding characteristic of a culture is its resistance to change. They have reached the conclusion that change takes place suddenly in particular places, and that periods of sudden change are separated by long periods of time during which the basic ways of living remain untouched. Sudden change usually takes place in locations where for one reason or another the influences of several quite different cultures are brought together.

Viewed in the larger perspective, man's ways of living on the earth can be shown to have advanced from simple to complex in three major steps as well as in a large number of minor steps. The first two of the major steps were taken before the beginning of written history. The first step was the discovery of the use of tools and mechanical devices to aid human muscles; it was made ages ago by the manlike ancestors of the human species. The second major step was taken some time later when men first learned how to make use of domesticated animals and crops. There are some people today who have not yet learned to use domestic animals or to plant crops, but such people survive only in remote places. The anthropologists tell us that both these ancient steps in man's adjustment to the land were followed by centuries of confusion and readjustment, when the basic traits of man's cultures were subjected to fundamental revision.

The third major step in man's progress is being made, and we live in the period of turmoil which any basic change in way of living must inevitably produce. January 5, 1769, is a date of profound importance to mankind, for on that date James Watt patented his first successful steam engine. This was the first important use of controlled inanimate power, and the application of this new technology to the problem of making a living from the land has produced changes so fundamental that human life on the earth is being revolutionized.

The emancipation of man from a life of hard physical labor for the production of bare necessities began with the nineteenth century. Once the basic techniques of natural science, invention, and engineering had been learned, new control over the forces of the physical earth came at a faster and faster rate, until now the prospect of controlled atomic energy is before us. As a result of all this, the mechanical aspects of life have been transformed. Transportation has been so completely changed that now, for the first time in human history, it is possible to transport vast quantities of foods and other materials from one part of the earth to another. Inanimate power applied to industry has so immeasurably increased man's capacity to produce useful things from earth resources that it has now become mechanically possible for all people to live in greater material comfort than was possible for kings in centuries past. Inanimate power, together with the products of industry applied to agri-

culture, has rendered time-honored farm techniques obsolete, and has transformed lands which were once rated as poor into lands of high productivity. The capacity of man to produce the essentials of food, clothing, and shelter has been enormously increased in the period of less than two centuries, and this increase is on a scale vastly greater than any previous change in such capacity since the domestication of animals and plants. But with all this remaking of the mechanical aspects of life, the economic, social, and political institutions and the moral values of man's cultures still retain many forms developed in an earlier period and not yet harmonized with the new capacity to control and utilize the physical resources of the earth through co-operation and interdependence. Because of this lag, these same newly acquired powers, incredible as it may seem, have been used to destroy not only the resources of the earth, but man himself. The suicide of the human race is so dangerously near that men no longer know whether to face the future with optimism or despair.

OCCIDENTAL CULTURE

At the dawn of the industrial era most of the people of Europe practiced the same basic techniques and were familiar with the same kinds of institutions. This was the *Occidental culture*, which had had its beginnings in classical antiquity in Egypt, Mesopotamia, Greece, and Rome, and had been only slightly developed or modified in its fundamentals during the long course of pioneer settlement in Europe north of the Alps. The outstanding fact concerning pre-industrial Occidental culture was its dependence for power on human or animal muscles or on such uncontrolled inanimate power as wind or falling water. Because the absolute necessities of food, clothing, and shelter had to be largely provided by human work, the greater proportion of the labor of Occidental people was expended for bare subsistence. Only the few who owned title to the land enjoyed freedom from want, social prestige, and political power. And in this system of feudal lords most of the land was divided into vast private estates. The many whose incessant toil supported the whole system were clustered about the great castles, or within the walled towns where soldiers could give protec-

tion. Along with the lords, the officers of the army, the priests of the church, and at least the higher officeholders of the governing bureaucracy enjoyed positions of prestige.

This society has been described as an "illiterate agriculturalism." Most of the people had no time to lift their eyes from the land on which they labored. With the traditional farm techniques widely in use, yields per acre were small (wheat, for instance, gave only from six to ten bushels to the acre); and each community was entirely dependent on the food products of its immediate vicinity. It was a system of local self-sufficiency, of economic independence for small areas. Because transportation overland was slow and costly, only luxury goods of high value could be brought from distant places, and such goods were of interest only to the small minority of well-to-do people. Local crop failure meant famine, even if supplies were abundant in some neighboring area perhaps less than a hundred miles away. Only where sailing ships could bring bulky products to seaports could commerce reach out to the foods and raw materials of many distant places. Especially in England and around the continental shores of the North Sea, commercial towns made their appearance early, and to these places came not only the goods but also the ideas of many people all around the world oceans.

The Industrial Revolution began in England in the late eighteenth and early nineteenth centuries. With it came such profound changes in the accustomed ways of living that many aspects of the traditional Occidental culture disappeared and new traits made their appearance. For the first time in history the presence of coal underground became significant in the location of people. With power furnished by steam engines, large industrial establishments could produce not only the essentials of life but also the luxuries in much greater quantities and at much lower cost per unit than had ever been possible before. Quickly the luxuries became so widely used and life was so quickly adjusted around their use that these new items became necessities. The traditional prestige of the owners of the land was challenged by the new economic and political power of the owners of capital; that is, of the tools or machines with which people worked.

The new system raised the general level and security of living. Not that everyone was now able to be free from wants; in fact, one of the

peculiar traits of the new way of living is the continued expenditure of effort to increase the wants, and so the frustrations, of the people. But compared with the way of living in the pre-industrial society, the variety and certainty of the foods, the quality of the clothing, and the adequacy of shelter were all raised to an unprecedented level while the hours of labor were decreased. Along with these changes came the enormous increase of commerce and the growth of education, of democratic institutions, and of scientific ideals and humanitarian sentiments.[1]

The unprecedented scale on which goods were exchanged in the new system gave significance to locations where natural routes of travel converge. Here cities grew. Great cities—that is, cities of more than a million inhabitants—made their appearance for the first time in history. London passed a million in 1802; Paris about 1850; New York about 1870; Vienna in 1878; Berlin in 1880; Tokyo, Chicago, and Philadelphia about 1890; Calcutta in 1900; Buenos Aires about 1906. Today there are fifty-one great cities in the world.

The use of controlled inanimate power made these cities possible. Previous to the use of such power so many people in such a small area could not have been supplied with food. But with the development of railroads and ocean ships, an urban population was able to devote itself to commerce, manufacturing, and arts and sciences, or to serving other people in these professions; and such non-food-producing people could be supplied with food from distant sources of supply so scattered that local crop failure had little effect. The urban people can produce so much beyond their own needs that they have plenty to exchange with those who supply them with things they lack. But never before the present time has there been such a demand for the raw materials of the earth. The mining of ores and fuels, the cutting of forests, and the exploitation of all resources have proceeded on a scale never before imagined.

The new industrial society by its essential nature was global in its scope, international in its needs. Local self-sufficiency had to be abandoned for world-wide economic interdependence. Society had the possibility of building with all the varied resources of the earth; but in so

[1]Kingsley Davis, "The World Demographic Transition," *Annals of the American Academy of Political and Social Science*, January, 1945, pp. 1–11.

doing, society became vulnerable to any natural or human disturbance of the steady flow of traffic along the new lines of transportation. The old economic, social, political, or military forms became insufficient because the new society could accept no limitations but the globe itself.

The industrial society had its origins around the shore of the North Sea in Europe. In England, northern France, and parts of neighboring countries, the Industrial Revolution introduced the new way of living more than a century ago. This change can now be studied only in the history books. But the transformation did not stop there. Like ripples on the water, the industrial way of living spread from this center. It came quickly to the United States, Canada, Australia, and New Zealand. It moved more slowly eastward into parts of Germany and Austria, and southward into northern Italy. At present it is making its appearance in the great cities of Latin America—in São Paulo, Buenos Aires, and Mexico City. Elsewhere in the Occidental world the older way of living still exists, only slightly modified by contacts with the centers of industry. In such places great resistance has developed to the profound changes which follow industrialization. The Fascists have attempted to select certain aspects of the industrial way of living and to reject the others. Along very different lines the people of the Soviet Union are attempting to do the same.

As a result, Occidental culture is no longer one thing. To describe its relation to the land it is necessary to recognize three major subdivisions in the world today, each with notably different attitudes, objectives, and stages of technical skill. These are: the *industrial society* itself, where the transformation of life along urban-industrial lines has gone the farthest; the *pre-industrial society*, where illiterate agriculturalism still persists; and the *soviet society*, where a revolutionary communism has rejected private ownership both of land and of capital, but where the technical skills of the industrial society are being hurriedly learned.

OTHER CULTURES

The Occidental culture has done more than transform itself, however. Especially is this true of the industrial society, which, because of its world-wide needs, has now reached out to the most remote parts of

the world. Today very few people remain anywhere whose way of living has not to some extent been changed by contact with Occidentals; and such contacts have in many cases been disastrous for the primitive peoples.

The world's simpler cultures are quickly wiped out by contact with the Occidentals. Consider the case of a hunting people, where the number of hunters is in delicate balance with the supply of game animals. Into such a community the Occidental trader comes to establish a trading post, seeking, perhaps, such high value products as furs. He sells firearms, among other items, in exchange for furs. But firearms quickly upset the balance of hunters and game, and very soon indeed the hunters are forced to flee from their traditional lands because of the lack of food. Around the trading post, or, with good luck, around a mission station, the poverty-stricken remnants of the hunting people are clustered, an easy prey to the white man's diseases against which they had developed no previous immunity.

Contact of the Occidentals with the somewhat more complex cultures of the Orient has also brought changes of enormous significance. The Japanese had adopted certain aspects of the industrial society, but these aspects, superimposed on the ancient traditions of an Oriental people, brought about a war of unprecedented destruction. Industrialization has also come to parts of India, Java, and China. Some of the more optimistic of the Chinese thinkers believe that a new culture—neither wholly Oriental nor wholly Occidental—will be evolved out of the present chaos of the Asiatic world.

THE INDUSTRIAL SOCIETY AND POPULATION

One of the far-reaching results of the growth of the industrial society has been the increase of population. Before the beginning of the nineteenth century the population of Europe, for example, was increasing slowly from about 100,000,000 in 1650, to about 140,000,000 in 1750, to about 187,000,000 in 1800. Birth rates were high, but so were death rates. Deaths, especially of children, were due to lack of hygiene, to poor nutrition, and to poverty. Famines and epidemics prevented any very rapid increase of the population. But during the eighteenth and

nineteenth centuries population suddenly expanded: cities burst from inside the ancient walls that had long protected them; forests were cleared and new farms established farther and farther from the market centers. By 1900 there were 400,000,000 people in Europe, and by the middle of the century there will be nearly 600,000,000 people.

Not only did population grow in Europe, but from that continent came one of the greatest migrations of history. More than 50,000,000 people left Europe in the century after 1846. Most of them poured into the United States, but large numbers also went to Argentina and Brazil in South America, to Canada, Australia, and New Zealand, and to many other places. Between 1775 and 1940 the population of the United States increased from 2,500,000 to over 140,000,000—a growth which has no equal in all history.

The growth of population with industrialization is a common phenomenon. The industrial way of living brings better food supplies, less danger of local famines, larger economic opportunity, an increase of literacy and education, and better hygiene and sanitation. The result is a drop in the mortality rate, especially among children—a drop which began slowly in the early nineteenth century, but which continues at an increasingly rapid rate. Birth rates at first remain high, but after a lag they too begin to decline at a more and more rapid rate. The net result is a period of very rapid population increase, followed by a decline in the rate of growth, and finally the achievement of a nearly static population again. The whole cycle has been passed through in parts of western Europe; and it has gone well beyond the peak in the United States, Australia, New Zealand, and Canada. It is just beginning in the Soviet Union, however; and what will happen following the industrialization of China, India, and Java remains a major issue not only in the economic problems of the world but also in the problems of political reorganization.

The period of expanding population was an extraordinarily prosperous one in the Western world, especially in those oversea countries where Europeans were able to move out into new first-class lands, as in the United States. As cities grew and markets for food products were constantly increasing, pioneer settlers moved onto new land from which the very scanty native population had been all but completely removed.

Railroads were extended to provide cheap access to markets. As new settlements appeared, as new railroads were built, as new towns were established, and as population as a whole continued to grow, there was a steadily increasing market for the manufactured products of the cities. Steady expansion—interrupted, to be sure, by panics and depressions, but nevertheless always going on to new heights—this was the basic characteristic of the nineteenth century capitalist society. And in both country and city the increase of population and the spread of settlement brought about a great increase in land values—the so-called "unearned increment" of the economists. This increase of land value is the basis not only of many large fortunes but also of a vast number of small ones.

Now Europeans in Europe as well as those who have gone overseas face a new dilemma. Especially in the United States, there are many who express a deep faith that the process of expansion can continue indefinitely. Even if population no longer increases, they say, there are still untold industrial frontiers. Yet the basic fact remains that in the late stages of the cycle of change, population again becomes relatively static; and continued business expansion lacks this solid social foundation of expanding numbers of individuals. The unearned increment has been collected. No first-class new lands are available for pioneer settlement.

As we find ourselves facing the need to adjust to a static society, we also find that the capacity to produce not only basic needs but also luxuries has enormously increased. The main problem today is to readjust the economic, social, and political forms of our culture, most of which we inherit from before the Industrial Revolution, to the facts of modern mechanical and technical skill.

Under all the confusion and uncertainty of this extraordinary period of human history in which we are privileged to live there is the fundamental fact that no human society can long survive which fails to establish workable connections with the resources of the land. Even our highly productive technical skills will not insure survival if we squander the essential raw materials of the earth without thought of replacement. Many of the simpler cultures have been more successful than we in the establishment of permanently workable connections with the land they

occupy. In the United States we have used forests, minerals, and soils at rates which, if continued, cannot fail to bring us to disaster. Even the much publicized "substitutes" developed during World War II by the chemical industries require the use of raw materials from the earth.

Whether the resources of the earth are sufficient to maintain a permanent industrial society in which all the world's people might participate is a question. There are some who insist that if earth resources are used in accordance with the best techniques, there is "enough and to spare"[1]; and that only the wasteful methods dictated by the division of the earth into sovereign states, each desiring self-sufficiency, or by the nineteenth-century system of exploitation for private gain, or by the wars on the scale of those in the modern era, can destroy resources so fast that man may again be faced by basic lacks. On the other hand, there are others who quote the enormous figures of production which would be necessary if all the world's people were raised to what is commonly described as a minimum standard. To provide all the world's people with such a standard would, according to a United Nations committee, require increases of production of the following order: cereals, 50 per cent; meat, 90 per cent; milk and other dairy products, 125 per cent; vegetable oils, 125 per cent; and fruits and vegetables, 300 per cent.[2] The question is whether our capitalist economy or any other system could manage to develop and maintain such vast increases in food production at sufficiently low cost. The answer is not clear.

Before these problems of social science can be studied profitably, it is essential to examine the present distribution of people in the world and their relations with the resources of the land. For what befalls the human race in the centuries ahead will, in part, flow from the present; and, similarly, to understand the present it is necessary to go back to origins and trace developments. The present pattern of people is obviously not a static thing; it is a stage in a process of which the two basic elements are the human culture and the land.

[1]Kirtley F. Mather, *Enough and to Spare*, New York, 1944.

[2]Quoted in Guy Irving Burch and Elmer Pendell, *Population Roads to Peace or War*, Washington, D. C., 1945, p. 30.

The Land

In human problems, as we have said, the land plays a neutral role. It has often been likened to the stage setting on which a drama is taking place. But the stage is a very complex thing, and it contains many items of no significance to the action of the play, and many other things which come temporarily into importance during a particular act or scene. The physical patterns of the earth should be considered as something entirely separate from the human patterns, although, to be sure, in each region, district, or locality there is the constant need to adjust human activities to the conditions of the land. To the human drama, however, the land remains neutral—neither favorable nor unfavorable in itself, but only as the play gives it these qualities. Furthermore, in terms of the human time scale, the land is relatively permanent and enduring. Man with his comings and goings, his wars, even his ideals and aspirations, seems small indeed when measured against the earth, the surface of which he inhabits.

THE MAJOR LINEAMENTS

The face of the earth itself is an extraordinary place. In spite of the wide range of possible temperatures that exist in nature, from the tremendous heat of the hottest star to the appalling cold of the outer reaches of space, here at the earth's surface are found air temperatures at which water will neither freeze nor boil. All the organic forms we know, including man, are dependent on the fact that life is only possible in the presence of water, which is a liquid. The distribution of water on the earth is a basic fact of existence.

Among the major lineaments which make up the face of the earth are the continents and ocean basins. The continents are composed of relatively upstanding masses of the earth's crust between relatively down-sinking portions, which make up the ocean basins. The difference in elevation, or relief, above the center of the earth of these contrasted parts of its surface averages only about three miles, or less than 1/1300 of the radius. The maximum difference in elevation is about 12 miles (between Mount Everest, about 29,000 feet above sea level, and the ocean deep off the Philippine Islands, about 35,000 feet

below sea level). But even this is only about 1/330 of the earth's radius. Small as are these differences of elevation compared with the size of the planet, they nevertheless measure the major relief features of its surface.

Only about 28 per cent of this surface, however, stands above the sea. Water fills the ocean basins and, overflowing these, inundates also the margins of the continental masses. As a result the continents are for the most part isolated, while the oceans are relatively continuous. There is more than twice as much land north of the equator as south of it. Except for Antarctica all the continents are broadest in the north, even those in the Southern Hemisphere. There is an almost complete ring of land around the basin of the Arctic Ocean, while, in contrast, the tapering of the continents toward the south leaves an almost uninterrupted sea in the higher middle latitudes of the Southern Hemisphere.

All these various continental masses are tied together by more or less continuous chains of high mountains. These mountain ranges, passing from continent to continent or festooned around the oceans in strings of islands, form a framework to which are joined the other major lineaments of the earth's face. Without regard to the complexity of detail at this time, the general distribution pattern of high mountains is one of relative simplicity but profound significance. In a sense the central and southeastern part of Asia is the core of the world's lands, and in the present-day world it is composed of a complex knot of towering mountain ranges. From this core mountain axes extend in three directions: one westward through southern Asia, southern Europe, and northern Africa to the edge of the Atlantic Ocean basin; and one northward and one southward to form, through the American continents and the Pacific margins of the Antarctic Continent, a broken ring of mountains around the basin of the Pacific Ocean. The manner in which the several continental masses are joined to this framework gives to each its own peculiar shape. Yet these various lands, when plotted on a polar projection, appear as three peninsulas radiating from the Asiatic core (Fig. 1): Europe and Africa, depending from the western limb of the mountain system; the East Indies, Australia, and New Zealand, depending from the southern limb; and the American continents, attached to the limb which starts northward through eastern

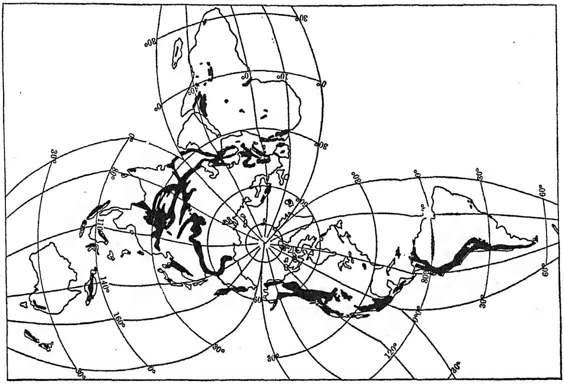


Fig. 1. *The arrangement of mountains and continents*

Asia and crosses into the Western Hemisphere through Alaska. The land masses of the world, therefore, are not symmetrically arranged with reference to the poles and the divisions of latitude and longitude.

All these features would appear as major lineaments of our planet if it were viewed from a distance—let us say by an observer on the moon. The patterns of land and water distribution and the chains of high mountains would probably stand out conspicuously. But, in addition, the land areas outside the mountain regions would probably be divided into a mosaic of lighter and darker patches. The relief of these nonmountainous areas would be inconspicuous, but the cover of natural vegetation would provide great contrast from one region to another. The chief vegetation types—the forests, the grasslands, the deserts, and the tundras—must also be included among the major lineaments.

These vegetation types are the visible reflection of the climates. They are the great climatic emblems. The regions of light rainfall or continuous cold are but scantily covered by plants; the regions of heavy rainfall, on the contrary, are forest-covered; the forests of the hot lands

are dense and luxuriant compared with those of the cooler regions; even the rhythm of the seasons finds expression in the changing aspect of the vegetation cover.

The climatic features, unlike the land masses, are systematically distributed over the face of the earth. In a general way latitude is a control of climate; but the simple arrangement of climatic zones parallel to the equator is broken up by the great differences, at the same latitude, between climates developed over the oceans and climates developed over the lands. To the ancient Greeks we owe the concept of "klimata," or zones based on differences of latitude; and the persistence of the old five-zone division of the climates is a tribute to its simplicity. But the old "torrid, temperate, and frigid zones" represent an oversimplification of the facts of climatic distribution and cannot be given any place in a modern treatment of that subject. Nevertheless, the arrangement of the different kinds of climate is systematically controlled in part by latitude, in part by differences of land and water, and in part by various other influences of lesser importance. Over each continent, therefore, at a given latitude, the arrangement of the climates and of their visible expression in the climatic emblems forms a strikingly similar pattern. Without mountains the similarity would be very great; the actual differences of design which distinguish one continent from another are in large part the result of the mountains.

For the purposes of this book eight major groups of natural regions are adopted. Each group includes regions in different parts of the world which are broadly similar with respect to the surface features and the natural vegetation. Although the process of human settlement has so completely transformed the cover of vegetation that to reconstruct its patterns on large-scale maps of small areas is frequently impossible, the reconstruction of the major patterns on small-scale maps of large areas can be done with precision adequate for the scale in all parts of the world except eastern China. Both surface features and vegetation are used in defining the groups: the first seven groups include regions which are nonmountainous, and are distinguished on the basis of the natural vegetation; the eighth group includes mountain regions. The order, as presented in the following list, is a matter of expediency.

GROUP I
The Dry Lands

GROUP II
The Tropical Forest Lands

GROUP III
The Mediterranean Scrub Forest Lands

GROUP IV
The Mid-Latitude Mixed Forest Lands

GROUP V
The Grasslands

GROUP VI
The Boreal Forest Lands

GROUP VII
The Polar Lands

GROUP VIII
The Mountain Lands

In the chapters which follow we shall discuss the nature of the physical land and the experience of human societies in forming connections with the land in each of these groups in turn. Yet as we consider the different regions of the earth we are constantly reminded that the industrial society, with its great urban concentrations of people, its incredible capacity to produce things from the resources of the earth, and its great need for raw materials on an unprecedented scale is essentially global in its scope. There is still the same basic necessity to form workable connections with the land, but the connections can no longer be restricted to any one locality. In the concluding chapter we shall return to the global view of human society, when we are better prepared to understand the interregional, intercontinental, and international relationships which the new technology seems to make possible.

GROUP I

THE DRY LANDS

Water and sunlight are the basic needs of life. In the dry lands of the earth there is abundant sunlight, but the supply of water is small. Over vast areas life forms can gain a foothold only by persistent struggle against drought, or through ability to endure long periods without water and to carry on the life processes hurriedly and vigorously during those rare periods when water is available. However, in those spots in the dry lands where water is present a most amazing exuberance of life exists.

Man too concentrates his activities on these wet spots. His problem is constantly to maintain or enlarge his supplies of water. Yet for all his efforts an almost negligible proportion of the deserts has proved permanently habitable. The rich green of the oasis vegetation and the teeming activity of the numerous inhabitants are set in striking contrast against a background of barren solitudes. Beyond the sharp line which separates the land of life from the land of death one enters another world, a strange and unnatural one for those who are familiar with the abundance of growing things where rainfall is adequate. Here the land needs only water to make it bloom, but, lacking only water, it has remained a wilderness.

The Land

DESERT CLIMATE AND DESERT VEGETATION

The basic fact concerning the dry lands is that they are deficient in moisture. Much more water would evaporate during the average year than is supplied by the rainfall. In most deserts rains come only at infrequent and irregular intervals, many years elapsing between showers. When rain does fall, it comes in the form of cloudbursts, tremendously heavy downpours sometimes accompanied by hail and lasting several hours or even several days. Damage by floods, strange as it may seem, is a characteristic occurrence in deserts; for the heavy rains are all the

more destructive because of the lack of well-defined stream channels, the sparsity of vegetation, the hard-packed soil, and the character of the buildings and other human works which are not made to withstand much water.

Very few parts of the world are truly rainless, although portions of the Libyan Desert and of the Atacama Desert approach this condition. In all deserts the hills and mountains receive more rain than the flatter lands. Over some of the higher ranges clouds may hang most of the time, supporting a little green pasturage in the cloud zone throughout the year; but even here the rule of desert rainfall is irregularity and uncertainty.

Temperatures in the dry lands vary considerably according to the latitude. In the poleward portions of the deserts, especially in the Northern Hemisphere, the winters are very cold. At lower latitudes, however, are found the highest air temperatures ever recorded at the face of the earth. Death Valley, in California, formerly held the record with a temperature of 134.1°[1]; but not long ago this was exceeded by Azizia, located about twenty-five miles south of Tripoli, where the temperature reached 136.4°. Temperatures well over 100° occur regularly during the summers in all but the poleward areas or in areas close to the oceans. Such heat, together with the glaring reflection from the bare desert surfaces, aggravated by the clouds of dust which the desert winds pick up, makes traveling in the afternoon hours uncomfortable or even difficult.

The desert night, on the other hand, generally brings a rapid drop of the temperature. Especially on elevated plateaus the surface of the earth cools rapidly under the clear night sky, and great diurnal ranges of temperature are the result. In fact, the desert holds the world's record for this also; in the Saharan oasis of In-Salah the temperature ranged from 26° to 126° within twenty-four hours.

Desert Vegetation. These climatic conditions are reflected in the landscape by a characteristic type of vegetation cover. Contrary to

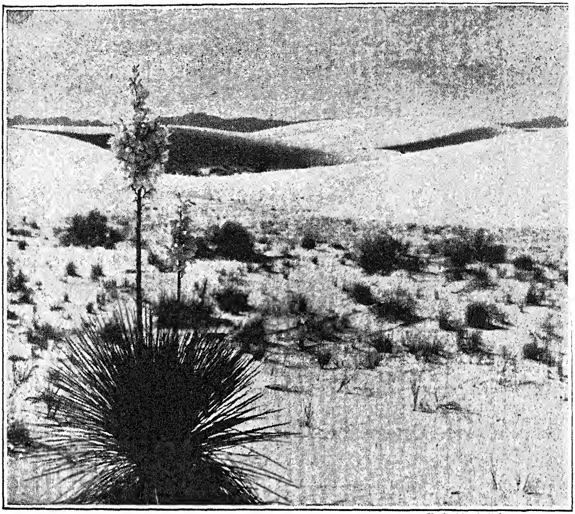
[1]Climatic data throughout this book are given in Fahrenheit degrees and in inches, unless otherwise specifically stated. Official air temperatures are always taken in a shelter which provides shade but does not shut out the wind.

popular impression very few parts of the deserts are entirely barren. Such bare places do occur, but they are rare. Even the great sandy deserts have a scattering of drought-resistant shrubs in the hollows between the dunes, and where water seepage brings moisture near the surface the result is a profusion of plants. The typical desert scene includes a cover of low shrubs and grasses, which, at least after a rain, gives the landscape a distinctly greenish tinge.

The vegetation which can exist under these extreme conditions of drought and high evaporation must be especially adapted to them. This is accomplished in various ways. There are annuals which evade the drought by lying dormant during the long dry period, springing into bloom and rapidly completing the life cycle during the rare intervals when water is available. Then there are the perennials which endure the drought, quickly sending forth leaves and stems during the periods of rain, but remaining brown and apparently dead as long as no moisture reaches them. There are also the succulent plants, such as the cacti, which resist the drought by storing water inside their roots and stems and by protecting themselves from evaporation by thick bark, by narrow, hairy, or waxy leaves, or by a complete absence of leaves. Such plants are protected also from the attacks of thirsty animals by an armament of thorns.

Desert plants usually grow some distance apart, and have a remarkable development of the root system—both laterally, to catch the infrequent rains, and vertically, to tap the deep-lying supply of water. The lack of a complete mat of vegetation over the surface is one of the distinguishing features of the dry lands. Because of the short growing season those plants which are especially attractive to insects, the carriers of the fertilizing pollen, have an advantage of survival. Hence among the most striking peculiarities of desert vegetation are the brilliant coloring and penetrating odor of the flowers (Fig. 2).

Plants which are adapted in these various ways to dry conditions are called *xerophytes*, or xerophytic plants. A scattered cover of xerophytic shrubs with bare ground between the plants is the characteristic natural vegetation of the regions of Group I. In fact, the lack of a complete cover of vegetation is the feature which distinguishes the regions of this group from those of neighboring groups.



E. C. Mitchell from Black Star

FIG. 2. *Desert vegetation in Death Valley*

Vegetation and Rainfall Effectiveness. The various plant associations included in the general term "desert" occur in areas which are deficient in moisture. But moisture deficiency is not solely a matter of low rainfall. Deserts cannot be defined as having less than, say, 10 inches of rain a year, because there are a number of things which combine to determine the effectiveness of rainfall in terms of plants.

When rain falls on the ground, part of it is evaporated again, part runs off over the surface, and part sinks into the soil. Only the part which sinks into the soil can be effective in the support of vegetation. The presence of only scattered xerophytic shrubs, therefore, may be the result of low rainfall, rapid evaporation, rapid drainage, or a combination of these. The rate of evaporation is much greater at high temperatures than at lower ones, and it increases also with lower humidity and

with higher wind velocities. And there are still other elements affecting evaporation. The amount of water which remains on the surface to be evaporated after a rain depends on the degree of slope, on the nature of the soil, and, to a certain extent, on the nature of the cover of vegetation. It also depends on the rate at which the rain falls, for much more water is soaked up by the soil in a long-continued drizzle than in one of those violent cloudbursts which are so typical of the deserts.

Desert vegetation, a visible result of moisture deficiency, is the product of all these numerous factors, some *climatic* (resulting from the average state of the atmosphere), and some *edaphic* (resulting from the character of the soil and surface). In general, the broad outlines of the desert regions are the result of climatic conditions, whereas the details observed in particular localities are the result of edaphic conditions.

Two examples from the United States will make clearer the effect of differences of temperature and rainfall in determining moisture effectiveness. Denver, Colorado, is located east of the Rocky Mountains in an area once covered by short grass. It is outside the dry-land region, with a climate which is described as semiarid rather than arid. Denver's average annual rainfall is 14 inches, which comes chiefly in summer and is therefore less effective than if it came when temperatures were lower. Denver's average temperature is about 50°. Under these circumstances the amount of rain necessary to support a continuous grass cover is about 10 inches.

El Paso, Texas, is located in a part of North America where the climate is arid, and where typical dry-land vegetation is to be found with bare ground between the plants. El Paso's average annual rainfall is just under 10 inches, and, like the rainfall at Denver, it comes chiefly in summer. The average annual temperature is about 63°. Experience indicates that at such temperatures more than 12 inches of rain are necessary for the support of grass vegetation.

The World Distribution of the Dry Lands. An examination of the maps (Plates 9–20) shows that the regions of Group I are more or less systematically arranged on the earth. They occupy a similar position on all the continents. They occur on the west coasts, roughly between

20° and 30° both north and south of the equator. In South America, to be sure, the desert extends much farther toward the equator than on any other continent, although in Africa, also, it crosses latitude 20°S. Allowing for the individual peculiarities of each continent, we can nevertheless find a desert on the west coast somewhere between these latitudes in all parts of the earth. The deserts also extend inland from the west coast, and as we follow them toward the continental interiors we note that they reach farther and farther poleward. In Somaliland and in southern South America the dry lands reach the east coasts, but elsewhere these parts of the continents have no moisture deficiency.

There are five great areas of desert in the world. These are listed in the following table, together with the regional names of the various parts:

1. North Africa-Asia
    Sahara, including Libya; Somaliland; Arabia; Iran; Thar; Turkestan; Tarim; Gobi
2. North America
    Mexican Plateau, Lower California, Sonora, Colorado Plateau, Mojave, Great Basin, Wyoming Basin, Columbia Plateau
3. South America
    Coastal desert of Peru, Atacama, Western Argentina, Patagonia
4. South Africa
    Kalahari, Namib
5. Australia
    Great Sandy Desert, Great Victoria Desert

The general world distribution of deserts is a result of the symmetrical arrangement of certain basic climatic features on the earth. Plate 23 shows that the west coasts of all the continents are bathed in part by cold ocean water, and that where the cold currents extend farthest toward the equator, as off western South America and western South Africa (Peru Current and Benguela Current), the deserts also extend farthest in this direction. The presence of a wide area of cold water off Patagonia (Falkland Current) also corresponds to the east-coast desert of southern Argentina. The Somaliland desert, however, is bordered by warm water.

The low rainfall, which is a major factor in moisture deficiency and so in the development of deserts, is a result of the failure of moisture-bearing air to reach these sections of the continents. The only important sources of moisture in the world are the warm parts of the oceans. From cold water there is relatively little evaporation, but the air over warm water picks up large amounts of moisture. When warm, moisture-laden air moves onto the land, the areas it reaches are supplied with copious rain. The world's deserts extend to the coasts only where the water offshore for a long distance is cold, or where the air blows parallel to the coast (as in Somaliland). The continental interiors, especially where they are protected by high ranges of mountains, remain dry because the moisture-bearing air cannot get into them. The world's wind systems which bring moisture to other parts of the continents will be discussed in later chapters.[1]

SURFACE FEATURES AND DRAINAGE

These great desert areas, however, are by no means uniform in character. The concept of a desert as a vast expanse of shifting sand is incorrect, for actually only a relatively small proportion of the dry-land area is of this sort. A much larger proportion is composed of rocky plateaus channeled by dry watercourses, or of basins surrounded by barren mountains.

Desert Landforms.[2] To a person used to the forms of hills and valleys in rainy regions the deserts are strikingly different. In the first place, because of the scanty covering of vegetation, even the minor irregularities of form are revealed—especially, late in the day, when the shadows make the relief stand out boldly. One notices, too, the prevailing absence of permanent streams, although in some deserts the surface is scored by numerous dry watercourses. Perhaps the most striking peculiarity, however, is the accumulation of rock waste, the

[1]The principles of meteorology and the methods of classifying climates are discussed in Appendix B.

[2]For a discussion of the forms and origins of the various kinds of surface features, see Appendix C.

flood of debris which masks the base of every hill and cliff and which fills the valleys and basins. In the rainy lands, with permanently flowing streams, the waste material is gradually carried away; but in the deserts, outside of the immediate valleys of the few streams which do flow through to the sea, the only agent which can carry off the loosened rock waste is the wind. Only the finer particles can be picked up in this way. In the rainy lands on the lee sides of the great deserts, accumulations of fine dust, known as *loess*, tell something of the extent of wind erosion.

Mountain and Bolson[1] Deserts. From the point of view of the larger surface features two chief kinds of deserts may be recognized. The first of these is hilly or mountainous; the second is of much lower relief and is composed of rocky plateaus and sand-filled basins.

The first desert type, known as the *mountain and bolson* desert, is characterized by scattered ranges of barren hills or low mountains separated by more or less extensive basins or bolsons. In this kind of country most of the rain falls on the highlands. Because of the steep slopes and the violent nature of the showers, a very large part of the rainfall runs off over the surface, rapidly eroding deep V-shaped ravines and gullies. Although the desert rains may be infrequent, and many years may elapse between showers, most of the work of sculpturing the mountain ranges is accomplished by the violent rains and resulting floods. When the flood waters emerge from the mountains and enter the bolson, however, their rate of flow is suddenly checked. Much of the load of sand and gravel picked up in the mountains is deposited in the form of alluvial fans which spread out in front of each valley mouth along the margins of the bolson. During a cloudburst, and for a short time after, water may actually cross the alluvial fans and reach the center of the bolson, there forming a temporary shallow lake. But the rapid evaporation speedily removes the water from such a lake, leaving in its bed an accumulation of dazzling white salt. In some of the larger bolsons enough water may enter to support a shallow salt lake permanently, like Great Salt Lake in Utah; but more commonly the lakes in the bolsons are temporary, known technically as *playa* lakes, their

[1]From the Spanish word *bolson*, meaning "pocket."

beds marked most of the time by salt accumulations left over from the repeated evaporation of water.

There are, then, three chief divisions of the surface of mountain and bolson deserts. There are the mountain ranges with their steep, rocky slopes; there are the alluvial fans smoothing the angles between bordering mountains and bolson bottoms; and, in the lowest part of the basin, there is the playa, either a shallow salt lake with fluctuating shores or simply a flat salt plain over which at rare intervals the flood waters may form a lake. It is the alluvial fans of such regions which offer the best sites for human settlement; for by irrigating the fans with water from the mountain streams and permitting it to drain off easily to the playa, rich oases may be formed.

Hamada and Erg Deserts. The second type of desert is composed of rocky plateaus of relatively slight relief, in some places interspersed with extensive sand-filled basins. The Saharan terms are adopted in Anglicized form to describe these features: for the rocky plateaus, the term *hamada*; for the sandy areas, the term *erg*.

Although the surface of the hamada is covered with a regolith of angular rock fragments, this mantle is not very thick and does not obscure the underlying rock. The character and position of the geologic formations are therefore of primary importance in determining the landforms of the hamada. Especially varied are the forms which appear in areas of stratified rocks where the strata are of varying degrees of resistance to weathering and erosion. The weaker formations are quickly excavated, leaving the stronger rocks standing out in bold relief as *mesas* or *cuestas*.

Many hamadas are shaped as broad, flattish domes. Erosion by streams or wind may strip off the layers of sedimentary strata from the higher parts of the dome, leaving a core of massive crystalline rocks exposed in the center. In desert areas many of the crystalline rocks disintegrate more easily than sedimentary strata, so that the rocks in the center of the structural dome may be worn away to form a surface basin. A few types of crystalline rocks, however, especially recent igneous rocks, may stand out boldly. Around the crystalline center a series of infacing cuestas correspond to the outcrops of resistant strata.

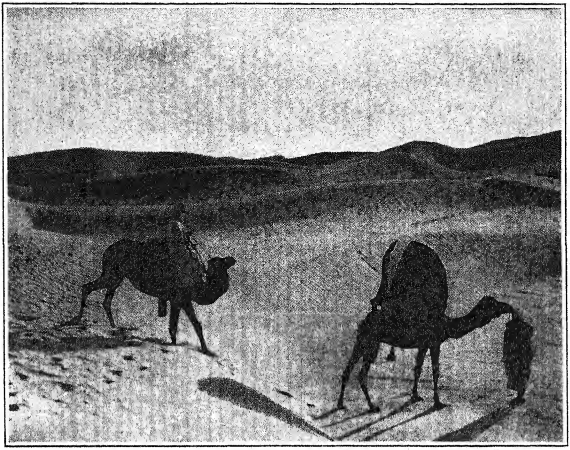
This is a common geologic structure not only in the dry lands but also in many other parts of the world.[1]

There are many other kinds of hamadas, however, besides those formed of simple horizontal layers of stratified rock or those produced by a broad doming. Some hamadas possibly represent the final product in the erosion of mountain ranges, and the neighboring ergs may be the filled bolsons of earlier geologic periods. It is not uncommon to find the monotonous surfaces of such hamadas surmounted by a few mountain remnants. Steep-sided pinnacles of crumbling rock rise so abruptly from the rocky platforms on which they stand that, viewed from a distance, they resemble islands rising from a sea. Because of this the Germans have given them the descriptive name *inselberge*, or "island mountains." All stages of transition, from the well-defined mountain and bolson desert to the subdued surfaces of the hamada and erg type, may be observed in the various parts of the world's dry lands.

The dry desert valley, cut, perhaps deeply, into the surface of the hamada, is a characteristic and striking element of the desert landscape. Excavated in the course of long periods of time by the recurring floods, these steep-sided ravines remain most of the time quite dry. When rain does fall, torrents fill the ravines from wall to wall; but as the waters subside, the load of alluvium which is being swept along by the floods is deposited in the channels. The ravine bottoms, therefore, are flat and are composed of a fill of coarse sand or gravel. To designate these dry desert valleys, the Arabic term *wadi* has been adopted (they are known as *arroyos* in the western United States).

Of all the desert surfaces, however, the one which is most familiar to people who have never visited the dry lands is the erg, or sandy desert. The ergs are extensive basins, or depressions, filled with sand which the wind forms into great dune ridges. Here we find the standard desert scene of the "movies," although actually this kind of surface is less extensive than any of the other types. Unlike the bolsons, the ergs do not usually have playa lakes, for the water which drains into them through the wadis of the neighboring hamadas is rapidly absorbed by the porous sands (Fig. 3).

[1]See the illustrations in Appendix C, especially Figs. 225–229.



Ewing Galloway

FIG. 3. *An erg landscape in the Sahara*

Water in the Deserts. The most important physical condition in the desert from the point of view of life is the occurrence of water. Knowledge of the places where fresh water may be found is of vital concern to desert dwellers, and habitability is in almost direct proportion to the amount of water which can be made available. There is a supply of ground water in most deserts, just as in humid lands, but the water table[1] lies at a much greater depth below the surface. Therefore the places where the water table can be reached by ordinary surface wells are few and far between.

In the mountain and bolson deserts, even where no permanent surface stream reaches the bolson from the neighboring ranges, water is usually to be found in the gravel fill of each mountain valley. As soon as the water reaches the alluvial fan it sinks deep into the porous mate-

[1]For a discussion of the occurrence of water and the meaning of hydrographic terms, see Appendix D.

rial and is difficult to reach with wells. The playa is of no value as a source of water; for even where moisture is abundant enough to support a more or less permanent playa lake, the evaporation renders the lake salty. Fresh water is usually not available even on the lower fan slopes. The best place to dig a well in such deserts is at the apex of an alluvial fan, near the mouth of a mountain ravine.

Water in the hamadas is most commonly to be found in the gravel fill of the dry valleys. Ordinary wells in the wadi bottoms are usually able to reach a fairly dependable supply, and if floods are not too frequent an almost continuous string of oases may become established along these dry stream-courses. Hamadas which are crossed by numerous wadis, such as the plateaus lying south of the Atlas Mountains in the western Sahara, may support a relatively large population. On the other hand, hamadas which are cut by few wadis, such as the Libyan hamada, west of the Nile, are among the least habitable portions of the deserts.

The water supply in an erg depends on the number of wadis draining into it. Where these are numerous, as on the southern slopes of the Atlas Mountains in western Sahara, the erg basins act as huge reservoirs, and the porous sands protect the water from evaporation and so from becoming salty. The hollows between the dune ridges are closest to the water table, and here a considerable growth of desert shrubs may reveal the presence of moisture not far below the surface.[1] But where the ergs are poorly supplied with water, generally because few wadis drain into them, the zone of saturation may lie so far below the surface that it cannot be reached even in the deepest depressions. Very dry areas, whether in ergs or hamadas, in which no forms of life can gain a foothold are known in the Sahara as *tanezroufts*.

In addition to the ordinary surface well, there is another important method of reaching water in the deserts. This is by means of an artesian well tapping a deep-lying source of water. Artesian springs may occur naturally, in some cases as the result of a crack, or fissure, in the bedrock. Not a few of the oases of the Sahara are dependent on such

[1]See the classic description of two Saharan oases, one occupying the hollows between the dune ridges of an erg, the other occupying the wadis of a hamada, in *Human Geography*, by J. Brunhes, Chap. VI, "The Oases of Suf and Mzab." Chicago, 1920.

Ewing Galloway

FIG. 4. *Sahara travelers getting water from a desert well*

a natural source of water. During the last century many artesian wells have been made artificially, either creating an entirely new wet spot in the desert or supplementing the ground water of an earlier oasis. Artesian wells are dependent on the existence of a certain geologic structure and may occur, where this structure is found, in hamadas or ergs or even, in some cases, in mountain and bolson deserts (Fig. 4).

Another important source of water in the dry lands is provided by the so-called *exotic* streams. The deserts as a whole are characterized by a lack of native surface streams rising within the areas of arid climate.

There are numerous cases, however, where streams rise in rainy areas elsewhere and maintain a flow across the dry lands. Such streams may be illustrated by the Nile in Egypt, the Colorado in the western United States, the Indus in Pakistan, the Loa in Chile, and many others. These exotic rivers have the peculiar character of decreasing in volume downstream and of lacking tributaries. Owing to the progressive loss of volume, they are constantly dropping a part of their load of mud, silt, and sand, which they are no longer able to carry, so that the river is split by sand bars into a number of distributaries, or separate channels. Such rivers are said to have *braided channels*. On entering a dry-land region, rivers tend to spread out in broad areas of shallow lakes or marshes and in some cases fail to continue across the desert, the water being evaporated so rapidly that the surface flow cannot be maintained. A comparison of the Niger, the Shari, and the Nile shows how these streams have spread out on reaching the desert margin.

Surface and Drainage Features in the Deserts. These various surface and drainage features are elements which give variety to the different desert areas. The actual distribution of these basic conditions is shown on the accompanying maps (Plates 9–20). These maps show that the Sahara and Arabia are mostly composed of hamada and erg surfaces, with only a few isolated mountain ranges. The deserts of Iran, on the other hand, are of the mountain and bolson type. The Thar Desert of India is composed of hamada and erg. The various deserts in inner Asia are built on a huge scale. They might well be considered as bolsons of continental proportions, with the Aral Sea or the Lob Nor as playas; but in addition to the usual features of bolsons, there are extensive areas of rocky plateau and erg. The Australian desert is composed of hamada and erg, whereas the desert of southern Africa is mostly hamada. The deserts of North and South America are mostly mountain and bolson, but with a few rocky plateaus, such as the Colorado Plateau in the United States or the Patagonian Plateau in southern Argentina.

All the desert areas except Australia are crossed by exotic rivers. Not all of them, however, are like the Nile, the Niger, the Tigris-Euphrates, or the Indus. The Colorado, except in its lower course, is deeply trenched in a canyon, as are also the Loa and the Orange.

Although the Amu Darya and the Syr Darya do not flow out to the sea, along their courses they are much like exotic streams.

The Occupance[1]

Only a small proportion of the world's population is found in the dry-land regions. Although deserts, as defined in this book, occupy about 18 per cent of the land surface of the earth, only some eighty-one million people, or about 4 per cent of mankind, live in them. Water and sunlight, we have said, are the basic needs of life: in the hot deserts of the world there is an abundance of sunlight, but a lack of water. This lack of water imposes a general limitation on the numbers of people who can be supported permanently in such regions; and although different cultures have from period to period of human history approached the problems of desert living in different ways, no culture has ever overcome the limitation on habitability imposed by scarcity of water. In the world's deserts we have a relatively simple relationship between man and the land because the basic problems are related to the scarcity of just one element—water.

Although the regions of Group I as a whole are occupied by only a small proportion of mankind, the places where water is available are among the most densely populated spots on earth. The Nile Valley, for example, is occupied by more than 1000 people per square mile. At the dawn of history the wet spots in the deserts were already populated more or less in proportion to the amount of water regularly available. The succession of ways of living in the desert as practiced by different people has brought great changes in the techniques of using water, and many of these changes have resulted in an increase or a decrease in the density of population. But, with certain exceptions, the pattern of

[1]The term *occupance* is an obsolete word revived and adopted in geography to indicate the process of occupying or living in an area and the transformations of the original landscape which result. A distinction is made between *occupance* and *occupation*. *Occupation* refers specifically to the economic activities of a people, that is, to their mode of gaining a living from an area or in an area. *Occupance* refers not only to these economic activities but also to other activities only indirectly or not at all related to the economic life, such as the construction of buildings, roads, etc. The occupance produces those "essential facts" of human geography described by Jean Brunhes (*Human Geography*, Chicago, 1920). The term *occupance* (occupancy) was first suggested by R. S. Platt and D. S. Whittlesey.

population—which bears a simple relation to the pattern of water—has remained the same.

Can the deserts be occupied by larger numbers of people than at present? Does the nature of the land forever restrict the habitability of these regions as compared with the wetter parts of the earth? It is generally true that the number of people dependent on agriculture that can be supported in an area is greatest in humid regions and in regions which are not too cold. Low rainfall and low temperature in the dry lands and in the polar lands create conditions which make widespread human settlement difficult or impossible. But to say that this would always and inevitably be true would be to go beyond the limits of our knowledge. Theoretically, at least, the way is still open for the kind of discovery or invention which will radically change the habitability of these regions.

So far as it is possible to predict, however, changes in the number of people that can be supported in the dry lands can only be small. In order to appreciate how small, it is necessary to examine the actual story of human settlement in certain of the world's desert regions. We need to know about man's experience in dealing with the problems of desert living.

THE WESTERN SAHARA

Nowhere is the record of man's experience with the desert longer or more varied than in the Sahara. The word itself means "The Great Desert." The popular impression of the Sahara as one vast sea of shifting sand is far from the truth, for actually the surface is mostly rocky hamada, surmounted in a few places by mountain ranges, and with scattered depressions occupied by sandy ergs (Plate 13). Something of the complexity of the Sahara is apparent on the map (Fig. 5) which shows the western part of the desert between the Mediterranean and the Sudan.

Not all the area shown on this map is desert. In the south the country around Lake Chad and south of Timbuktu on the Niger is a grassy savanna. In the north, similarly, there are grasslands along the Mediterranean and in the Atlas Mountains. The Sahara begins along the southern margin of the Atlas and a short distance south of the Mediterranean.

FIG. 5. *The western Sahara*

The Earliest Period of Human Settlement. The long record of human settlement in this area can be divided into three periods. The earliest period, which lasted in the western Sahara until near the end of the Roman Empire, was marked by the gradual invasion of the desert from the south by a Negroid people from the Sudan. The process had gone on for some time before the dawn of history, for the

earliest written records describe the wet spots of the desert as densely populated. These were the black people whom the Greek and Roman geographers interpreted as having been burned by living in lands which were too hot for white men. Neither the Greeks nor the Romans did much more than touch the northern fringe of the desert. For the most part the people who lived in the oases were isolated from the outside world; they were farmers, raising millet under irrigation for their own local food supply. Considering the tools at their disposal, it is evident that they did a remarkable job of tapping the water supply and applying it to the thirsty land.

In the western Sahara the wet spots where these people lived are not very different from the wet spots of today. The oases were mostly in wadi bottoms where wells could reach water seeping through the gravel. There were oases along the wadis radiating from the central part of the Ahaggar (east-central part of Fig. 5). Oases were strung out along the wadis descending toward the south from the southern range of the Atlas Mountains. In-Salah, located near the center of the map, was then, as it is now, an important oasis. So also were Ghadames and Ghat toward the east, where artesian water rises through a natural fissure to the surface. But the very dry area known as "The Tanezrouft," lying west of the Ahaggar, was entirely unoccupied. The ergs, except for a few spots where water entered them from the bordering hamadas, were also unpopulated.

The Moslem Period. The second stage in the human experience with the western Sahara began with the invasion and conquest carried out by the Moslem peoples, chiefly the Berbers and Arabs. This period began when two new things were brought into the Sahara from Arabia. These were the date palm and the single-humped camel, or dromedary. The Berbers, a pastoral people living to the west of the Nile along the Mediterranean shore, quickly adopted the date and the camel and, pushed on by the Arabs behind them, moved rapidly westward and then southward. Soon the wave of Moslem conquest brought the whole Sahara under control. The conquerors went far beyond: southward into central Africa, and northward across the Strait of Gibraltar into Europe.

The Berbers and Arabs brought fundamental changes to the process of living in the Sahara. Because of their great mobility with the camel they were able to travel swiftly from one oasis to another. They could practice pastoral nomadism on the marginal grasslands to the north and south of the Sahara, or on the pastures high in the mountains. But they also established their ownership of the oases. They were not interested in farming, and consequently they left the Negroid oases dwellers to tend the crops, returning only at harvest time to collect a share. But now the oases were made much more productive by the introduction of the date palm. New oases appeared in a few places—for example, in the Erg Oriental east of Touggourt, where the roots of the date palm could tap the ground-water supply in the hollows between the dune ridges, places which had previously been uninhabitable. Otherwise the pattern remained unchanged, but the number of people who were supported in each oasis was considerably increased.

Another major change was the organization of a caravan trade across the Sahara. From the Sudan the Moslem traders brought such high-value goods to the shores of the Mediterranean as ivory, ostrich feathers, or Negro slaves. From whatever part of the western Sudan these caravans originated, from Lake Chad to Timbuktu, they had to cross the Ahaggar, where oases provided food and shelter. The Berbers who lived in the Ahaggar grew rich on tolls levied on each caravan.

The European Period. The third and present period of human settlement started in the nineteenth century when the Europeans extended their conquest across the Sahara. In the western part of the desert the conquest was chiefly French. There was a long period of warfare with the desert tribesmen, but in the end came the recent but inevitable victory of the better-equipped Europeans. In other parts of the dry lands there are groups of people who remain semi-independent politically, but it is doubtful if any desert people could be found today whose way of living has not been changed, at least in its material aspects, by contacts with Occidentals. Even Ibn Saud, ruler of many scattered desert dwellers in Saudi Arabia, finds himself deeply involved with oil and with international strategy based on the position of the land he calls his own. In the western Sahara the once warlike Ahaggar tribes have been almost wiped out. Only a few hundred remain of a once powerful

people who collected tribute on every caravan that crossed the Sahara. Those who survive have adjusted their lives to the Europeans—they are garage mechanics, hotelkeepers, perhaps chaffeurs on the motor-stage route from Algiers to Gao on the Niger River. A few still tend herds of sheep, goats, and camels in the pastures of the central Ahaggar.

The first result of the European conquest was the destruction of the old way of living and, with it, of the individuals who could not adapt themselves to new things. But thereafter the Europeans built a new way of living. The date palm, used during the second stage for the production of food for both farmers and herders, has been developed as an export crop by the Europeans. With Occidental machines, large engineering works have been built to increase and regularize the supply of water in the oases. For example, there is now an almost continuous ribbon of date palms along the course of the Wadi Saura for some 750 miles from the base of the Atlas Mountains to In-Salah. Date culture has been extended, too, along the wadis radiating from the Ahaggar, such as the Igharghar, which leads northward, the Tamanrasset, which leads westward, the Tafasaset, which leads eastward, and the Tesselaman, which leads southward. These changes represent an extension of the wet spots, but no radical change in their pattern; they also mean a considerable increase in the density of population that can be supported. In addition, the use of well-drilling machinery creates entirely new oases by tapping the deep-lying artesian water. Whereas the sedentary oasis farmers of the first period were able to dig wells as much as 150 feet deep at Ghardaia, for example, in the hamada west of Touggourt, the Europeans can bore wells the depths of which are measured in thousands of feet. To be sure, the increased use of the underground sources of water has resulted in a decrease of the supply, and this decrease now threatens the whole pattern of settlement in this region. For a time, however, more area could be irrigated and more people could be supported in the desert. The Europeans have also substituted a commercial economy, based on the export of a surplus product and the import of goods from outside the region, for a subsistence economy, in which the people were entirely dependent on the products of their own locality. Can such a commercial economy be maintained permanently?

The geographers have a term which they use in referring to such a succession of different ways of living as we have just described. The sequence of different processes of settlement—of different modes of occupance—is called *sequent occupance.*

THE NILE VALLEY

The eastern Sahara differs in a number of important ways from the part we have just discussed. The extensive rocky hamadas of the Libyan Desert (west of the Nile Valley) are not surmounted by any ranges of mountains like the central part of the Ahaggar or the Tibesti Mountains north of Lake Chad (Plates 13–14 and Fig. 6). Consequently there are no extensive wadi systems such as those in the west. The Libyan hamada is a monotonous rock-covered or gravel-covered surface unbroken by wadis. In only a few spots are there breaks in the rocky surface which permit the deep-lying artesian waters to rise to the surface and form little natural lakes in the bottoms of small wind-blown depressions. Such are the oases of Kufra, Dakhla, and Kharga. But because of the absence of wadis, the hamadas outside these tiny wet spots offer no opportunities for permanent settlement. Libya is also one of the driest places on earth. The lack of pasture, as well as the small number of wet spots, in this eastern Sahara provided so little opportunity for the conquering Berbers and Arabs that this part of the desert remained very empty. No small part of the security which permitted the early flourishing of civilization in Egypt was due to the protection from outside conquest afforded by the very dry Libyan Desert on the one hand and the Red Sea on the other.

Through this desert flows an exotic river, the Nile, the waters of which provide the essential basis for the support of the Egyptian people. The Nile, rising in the mountains of equatorial Africa and emerging from Lake Victoria (Plate 13), and again reinforced by the torrential waters of the rivers descending from Ethiopia, has enough volume to continue all the way across the desert to the Mediterranean. Under natural conditions (that is, before the building of the Aswan Dam and other irrigation works) the river rose and fell in accordance with the floods poured in by the tributaries from Ethiopia. In the summer

there are heavy rains which descend in torrents through the rivers which drain this mountain country. The Nile, receiving this water, begins to rise sharply in May and reaches flood stage in September. During this time of the year about two thirds of the water in the Nile comes from Ethiopia. But thereafter, each year, the floods subside, reaching the lowest stage in April and early May. At low-water stage about 85 per cent of the volume comes from the main course of the Nile.

For thousands of years the Egyptians irrigated their lands by the natural floods of the Nile. The silt-laden water was permitted to enter diked fields and settle there, dropping the rich load of silt to form new soil. When floods were higher than normal there was plenty to eat; when floods were unusually low there was famine. The Egyptians attempted important engineering works to hold back the flood waters and increase the flow onto the land, but they were nevertheless subject to the changes in productivity brought about by the differences in the rainfall in Ethiopia from year to year. This type of irrigation is known as *basin irrigation.* It supported several million people in the irrigable area between Aswan at the first cataract and the Mediterranean. According to the census of 1882 (the first modern census), this system supported at that date about 7,600,000 people, or about 562 people per square mile of irrigable land.

The European Period. The British control of Egypt resulted in developments similar to those recorded for the western Sahara. The distressing effects of adopting European ways in Egypt are to a certain extent typical of similar effects elsewhere throughout the Moslem world. The problem of the relation of people to the land in Egypt lies in the background of the political and strategic questions which focus on this area today.

British engineers completed the construction of the great dam at Aswan in 1902. This dam held back the flood waters from Ethiopia so that irrigation was possible in the valley below Aswan at any time of the year, and with much greater regularity and certainty than ever before. Canals carried the water from the reservoir to the fields on either side of the river, and even into the Fayum Basin just west of the

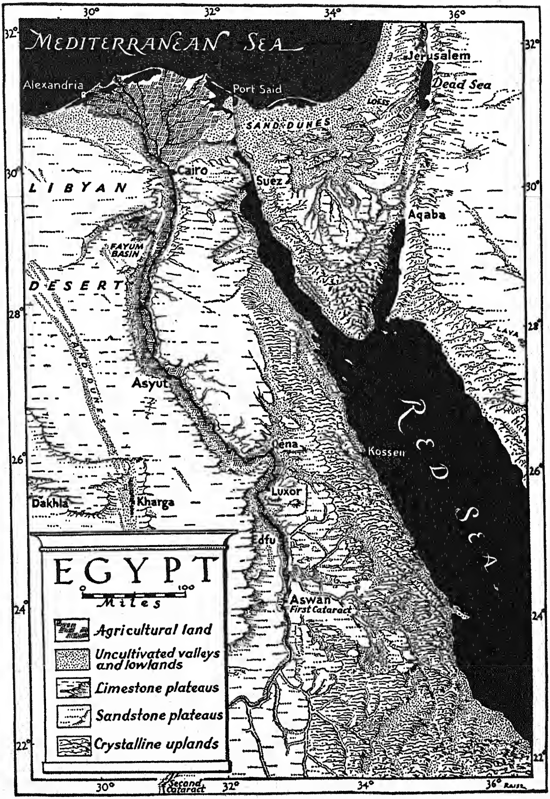


Fig. 6. *The lower Nile and adjacent territory*

Nile. The Egyptian farmers were no longer dependent on basin irrigation; they could practice *perennial irrigation.*

But the British traders wanted a commercial crop. No longer could the Egyptian farmers grow only the foods and fibers for their own immediate use, or for the use of the rulers and wealthy people who lived in Cairo and Alexandria. They were paid for the surplus production of long-staple Egyptian cotton, and with the money thus earned they could purchase imported manufactured goods or foods. There was a better and more certain food supply, and there was better attention to hygiene. As a result of these things, the Egyptian population began to increase at a rapid rate. In 1910 there were some 10,000,000 people in the country; by 1937 the number had reached 16,000,000; today there are well over 16,000,000. Measured in relation to the irrigable area of some 13,000 square miles, the density of population has now reached about 1200 per square mile, one of the greatest densities in the world for a people essentially dependent on agriculture.

There are a number of reasons why the average Egyptian farmer is poorer than he was before the European period began. Because Moslem law requires that an estate be divided equally among the heirs after the death of the owner, the farms have been divided and subdivided far below the limits of economic efficiency. In 1938 some 70 per cent of the owners of land had less than an acre each. Meanwhile, however, foreign capitalists or wealthy Egyptians had gained control of over two thirds of all the irrigable land. Only 7 per cent of the landowners controlled 68 per cent of the land. For these large landowners, a money crop was more important than a food crop.

And in addition, the yield of crops per acre was threatened. Since basin irrigation was no longer practiced, the Nile silt could no longer provide an annual enrichment of the soil. Meanwhile two crops a year were seriously depleting the soil fertility. It was increasingly necessary to apply fertilizer: either pigeon excrement, gathered in pigeon towers, which are now a common feature of the Egyptian landscape, or phosphate from local sources, or imported nitrate from Chile. All this has added to the cost of farming.

As the exceptionally high birth rate of the Egyptians continues, and as the high rate of infant mortality is attacked by modern medical

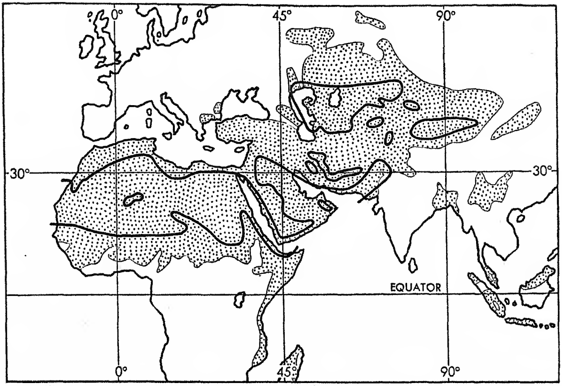


Fig. 7. *The Moslem World (after Bowman) and the arid boundary (after Köppen)*

services, Egypt faces disaster. Can it be that, after all, the Occidentals have failed to form a permanently workable connection with the resources of the land, and will the Egyptians have to pay the price in poverty and famine?

THE MOSLEM WORLD

The conditions in Egypt and in the western Sahara illustrate a situation which exists throughout the Moslem world (Fig. 7). The people of the Moslem faith occupy a large part of the dry lands of Africa and Asia and have spread beyond the dry lands in many places. Throughout this vast area there are some 250,000,000 people, most of them living in the bordering regions outside of the dry lands, some concentrated in irrigated areas, and a few widely scattered over the rest of the land. Most of these people are illiterate, ill-fed, ill-clothed, and in bad health. They are ruled by a small group of wealthy and powerful leaders or by foreigners. Today, more than ever before, their lands are coveted by outsiders, and for two reasons: first, along the Persian

Gulf in Iraq and Saudi Arabia, and in parts of Iran and Turkey, there are vast pools of petroleum only recently brought into production by the British, the Dutch, the Americans, and the Russians; and second, the central part of the Moslem world is in that highly strategic zone where the interests of the British and Americans touch those of the Soviet Union. The traditional "life line" of the British Empire crosses the dry-land zone through the Mediterranean, the Suez Canal, and the Red Sea. Security from attack along this line is desired by those who wish to maintain uninterrupted contacts with distant parts of the world. Meanwhile the vulnerable part of the Soviet Union extends in a long belt from west to east just north of the Black Sea. The Russians want security from attack from the Moslem lands to the south, and in addition, they have long desired an outlet to the warm waters and tropical products of the Mediterranean Sea and the Indian Ocean.

In the midst of these conflicting interests—both political and economic—are the scattered tribesmen of the Moslem world. Some are concentrated along exotic rivers, as along the Tigris-Euphrates or the Indus; some are in the narrow ribbons or miniature spots along the wadis of the Nejd hamada in Arabia; and some are scattered where water is available along the great alluvial fans of the deserts of inner Asia. But the Moslem world is not united politically, and even if it were, a dry-land base would scarcely provide the resources for a strong resistance to pressures from an industrial people.

THE TURKESTAN

The desert heart of the great continent of Asia is occupied by scattered groups of people. The distribution of settlement in the Turkestan, the dry country east of the Caspian Sea and west of the great mountains on the border of China, is illustrated by Fig. 8. This vast depression is made up partly of uninhabitable erg and hamada, and partly of alluvial fans built where the rivers descend from the bordering mountains (Plates 17–18). The Amu Darya and the Syr Darya support ribbons of irrigated lands as far as the shores of the Aral Sea, and lesser rivers provide the support for smaller oases. Along the mountain front are such famous old trading towns as Bokhara, Samarkand, Tashkent,

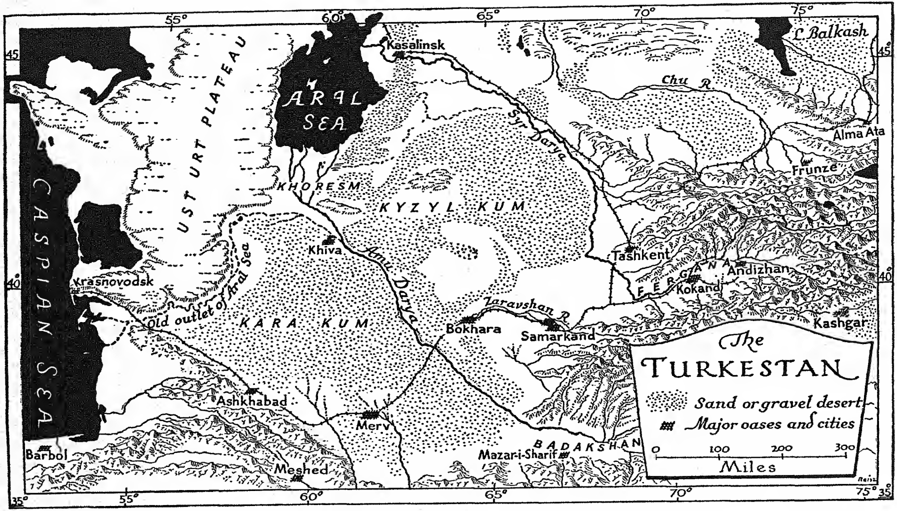


FIG. 8. *The southern portion of the Aral depression*

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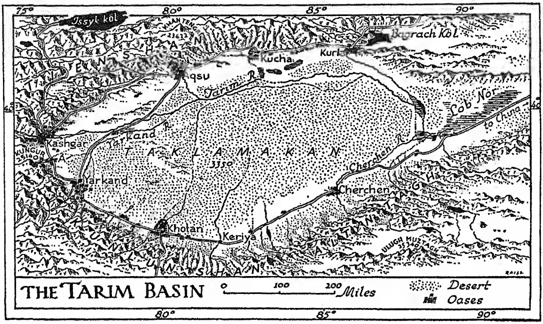


FIG. 9. *The Tarim Basin*

and Kokand. In these places caravans to and from China met those from Mediterranean Europe, or others from India or Iran. These places preserve the ways of ancient times, for the routes which pass through them are no longer of such importance as they were before the invention of steamships and railroads. Except where oil has been found there is little incentive for Occidental peoples to come in large numbers to such remote places.

THE TARIM BASIN

Another remote desert region of inner Asia is the Tarim Basin, which lies to the east across the mountains from the much lower and warmer Turkestan. Here is a vast depression many hundreds of miles across, its center occupied by an erg (the great Taklamakan), which is uninhabitable and scarcely even explored. Just as the waters of the rivers which flow into Turkestan are eventually brought together in the salty Aral Sea, so those of the Tarim Basin flow into the Lob Nor. The Lob Nor is composed of salt-encrusted flats, with here and there some salty marshes and seldom any open water. But where the rivers emerge from the mountains, near the apexes of the alluvial fans, an abundant supply of water is available, and here the oases are located.

From Kashgar and Yarkand the old caravan routes run eastward either along the northern edge of the basin or along the southern edge, passing from oasis to oasis. Along these routes, which eventually reach the populous eastern part of China, two-humped camels are still used to carry a small current of trade in highly valuable products. People are permanently settled only at the isolated wet spots, and in this remote region there is little likelihood that any serious attempt will be made to provide irrigation works to increase even slightly the productivity of the desert (Fig. 9).

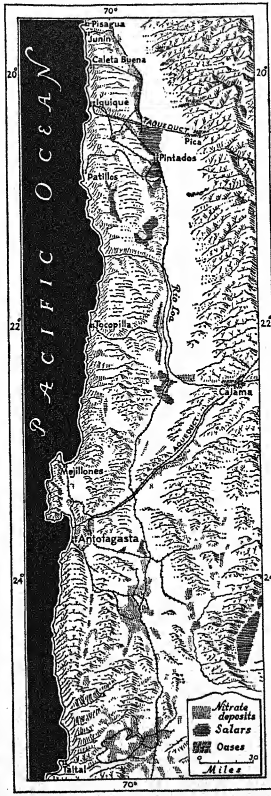


FIG. 10. *The Atacama*

THE ATACAMA

There are many other deserts of the world. The great Gobi of Mongolia, like the Tarim, is cold and wind-swept as well as arid. There are hot deserts, such as those of Australia, where isolated settlements are scattered many days' overland journey apart and where the few isolated settlers raise sheep for a meager living.

In Northern Chile there is the Atacama Desert, important because of the lesson it offers in the permanency of desert settlement. This desert (Fig. 10) lies between the Pacific Ocean and the very high western cordillera of the

Andes on the border of Chile and Bolivia. The land rises abruptly from the sea to an elevation of more than 3000 feet. But inland from this abrupt rise there is a long structural valley of gentle slopes extending parallel to the mountain front. Along the west-facing front of the Andes very small valleys emerge onto alluvial fans that stretch out westward as much as forty miles into the desert. But since the mountains are also dry, only those streams that rise in the snow fields above 20,000 feet in altitude carry water all the year round. The others offer only enough water to support small oasis communities—some of only a few hundred people. The only exotic river is the Río Loa, which emerges from the mountains near Calama, but shortly thereafter enters a deep gorge cut through the coast range and into the floor of the structural valley (Plates 11–12).

The Early Period. Human settlement in this region goes back thousands of years before the Inca rulers who lived in the mountains to the north established a route of communications through the Atacama to Middle Chile. The communications were maintained by runners who went from oasis to oasis along the mountain front. Each little oasis was built at the very apex of an alluvial fan, sheltered even within the mountain valleys. With water supplies very small, the best place to dig a well is exactly where the fan begins to emerge from the mouth of the valley. Farther out on the fan slope, the water is too far below the surface. Only where the rivers carry much water, as in the Turkestan, can the oases extend well down the fan slopes.

The European Period. When the Spaniards came to the Atacama the north-south line of communications was abandoned and east-west roads were built to the coastal ports. Calama, a relatively large oasis supported by the water of the exotic Loa, became an important Spanish settlement.

During the nineteenth century two important minerals were found in the Atacama. These were copper and nitrate. Big mining establishments were built, railroads were built to connect them with ports along the coast, and thousands of workers were brought into the region. In such a desert all the fuel, all the building materials, even all the food

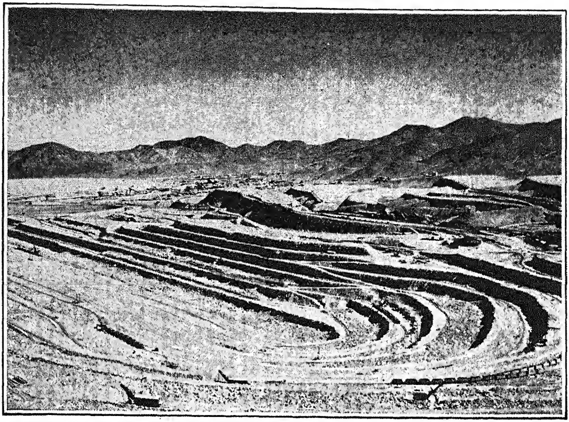


FIG. 11. *An open pit copper mine at Chuquicamata, Chile*

had to be brought in from outside to supply the mining camps and the ports. In some cases pipe lines, such as the one from Pica to Iquique, were built into the mountains to bring water to the mines. But in many cases water was actually brought in by steamer and distributed to the mining towns by tank car. Only such valuable products as copper or nitrate could pay the high cost of such expensive settlement (Fig. 11).

And then the mines had to curtail their production or shut down entirely. Copper was too abundant on the world markets, and nitrate was being produced from the air by a manufacturing process. Workers by the thousands had to leave the Atacama since they could no longer be supported there. Today production of both copper and nitrate continues at a reduced rate; but the time will come, and in the not distant future, when the supplies of these minerals are exhausted, and what then? The ports will be abandoned, since there will be no commerce to pay to keep the aqueducts in order or to import supplies. Only Calama and the ports that serve it will remain active. But the Indian

farmers along the western front of the Andes, long forgotten by the busy world of industry and commerce, will continue to occupy their little oases. They alone have formed a permanently workable connection with the land.

THE ORANGE RIVER

European settlement in the dry lands is not necessarily temporary, although the unregulated exploitation of resources for quick profit, which is an Occidental trait, makes continued settlement impossible in many places. In the Orange River region of South Africa (Fig. 12) we have an example of apparently successful settlement by European farmers based on irrigation. Much of South Africa is arid or semiarid, and the Orange River, like the Nile, rises in a rainy mountain region and flows as a dwindling exotic stream across country which becomes drier and drier.

In the larger sense, most of South Africa is a plateau standing 4000 to 6000 feet above the sea. The watershed between the Atlantic and Indian oceans is in a high and mountainous escarpment edge known as the Drakensbergen, which overlooks the coastal region around Durban. Many short swift rivers run to the Indian Ocean, whereas the Orange and its principal tributary, the Vaal, take the westward drainage from the Drakensbergen to the Atlantic over a course of 1640 miles. The eastern two thirds of this distance is through areas that receive an annual rainfall of from two to fifteen inches, with temperatures that permit a growing season throughout the year. Here the natural vegetation changes toward the west from a semiarid grassland to a true desert with only scattered desert succulents and almost no grass. Upstream, above the junction of the Orange and the Vaal, rainfall is more adequate, and cultivation of the land is possible without irrigation or with supplementary irrigation. Even in this humid area the rainfall is erratic in seasonal distribution and in amount. The Orange River system is unlike the Nile in that its waters come from only one catchment area. Thus the irregular rainfall at the source is translated into non-periodic occurrences of high and low water in the valley lower down. In the dry-land section, the Orange may be a raging torrent at one time and a series of stagnant pools at another, a

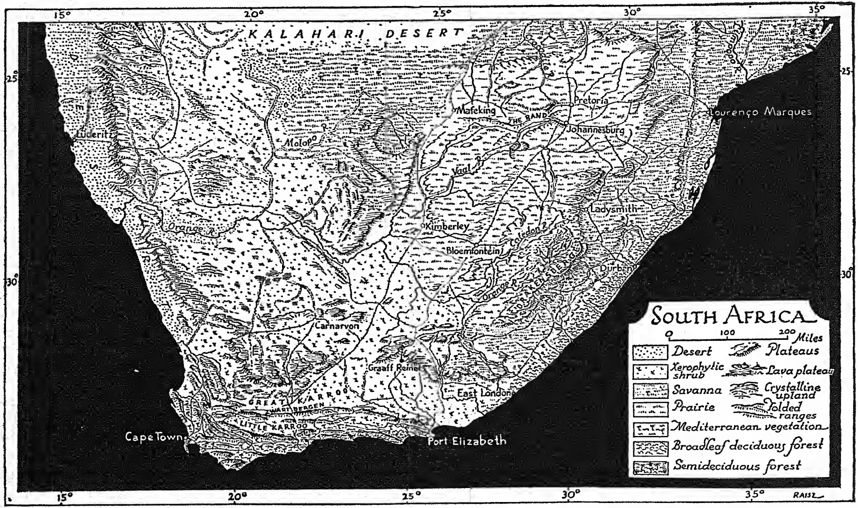


Fig. 12. *South Africa*

condition which makes irrigation difficult. Another difficulty is the narrow trench-like character of the valley. There are only a few places where alluvial land can be reached by canals and feeders and also be protected against floodwaters. And, finally, the dams and canals used to control the waters are quickly filled with silt because of the heavy burden of sediment carried by the Orange River.

Because of these difficulties only particular places are suitable for irrigation projects. One such area is the middle course of the Orange, where the valley is open and broad, with alluvial terraces, and the river itself is a braid of several channels enclosing low-lying silt and sand islands. Occasional narrows where hard rock structures are intersected by the stream provide sites for storage and diversion dams. Only a half century ago this middle course, where the rainfall is less than 10 inches a year, was occupied almost solely by pastoral Hottentot peoples who had been driven to the water by prolonged droughts. They made only primitive attempts to divert water to their gardens. The first farming project by white men in this desert was undertaken in 1894 at Upington, which is located where the northwest-southeast railroad crosses the river. At that place Boers (South Africans of Dutch-Huguenot ancestry) settled and developed the land under the auspices of the Dutch Reformed Church. The church and individuals sponsored other small but independent irrigation projects until, in 1929, the federal government of the Union built the Buchuberg Dam, some 100 miles above Upington, to act as a reservoir for all the improved land as far as the Aughrabies Falls, about 75 miles below Upington. Thus in the short span of one generation an oasis has been created where formerly mankind had no permanent habitation. Today the oasis has a population of 35,000, including the town of Upington (6400), which is supported by the intensive cultivation of some 70 square miles of irrigated land producing raisin grapes (sultanas), alfalfa, wheat, oranges, maize, and a little cotton.

The fight to win the land along this part of the Orange River has been successful; the fight to maintain the victory is still under way. The Buchuberg dam is silting rapidly, so that eventually other reservoirs (such as the Vaaldam, located north of Kimberley, 700 miles away) must be used. There is always the danger of extreme drought,

and the even greater risk of combined heavy floods on both the Orange and the Vaal, which might severely damage any irrigation works below the confluence of those rivers.

THE GREAT BASIN

There are deserts also in the United States and Mexico. The characteristics of the large area of inland drainage between the Sierra Nevada on the west and the Wasatch Mountains on the east are illustrated by Plates 9–10 and Fig. 13. This is a portion of the Great Basin —a mountain and bolson desert where flat-floored bolsons separate irregularly-placed desert ranges. Water from the high Sierra Nevada or the Wasatch Mountains is abundant and provides support for large oases; but from the desert ranges comes only a small supply of water, and here the oases are small and placed high on the fans. Sufficient water comes from the Sierras to maintain the flow of the Humboldt River far out across Nevada, even beyond the oasis of Elko. Carson City and Reno are surrounded by extensive irrigated lands. On the eastern side there is an almost continuous fringe of irrigated land on the alluvial fans of the Wasatch Mountains. The important cities are Salt Lake City and Ogden, in Utah. The rivers emerging from the Wasatch drain into Great Salt Lake, the fluctuating shores of which reflect the varying quantity of water supplied to it.

The sequence of settlement in the Great Basin is much simpler than that of the Sahara, or even the Atacama. The Indians of this part of America were a hunting people. The few who inhabited the Great Basin itself sought the wild game of the mountains and formed no permanent settlements in the bolsons. The first people of European origin to settle in the region were the Mormons, who, at Salt Lake City, established a farming community in a spot they hoped would be so remote that their persecutors would never reach them. In this hope they were disappointed, for the discovery of gold in California soon brought many travelers plodding westward across deserts and difficult mountain passes. The Mormons were caught up in the fabric of American settlement in the course of time and made a part of it. The isolated oases of the Great Basin were reached by railroads. From

a purely subsistence economy, the oasis communities adopted commercial crops which could be exchanged for the much-desired manufactured products of the eastern cities. Since these oases are too far north to permit such hot-desert specialties as cotton (which can be grown at Phoenix) and dates (which can be grown along the lower Colorado), the greater part of the irrigated lands in Utah and Nevada are used for growing summer feed crops to be fed to animals during the winter, and to such high-value but hardy crops as sugar beets and potatoes.

AGRICULTURE AND COMMERCE IN THE DRY LANDS

Looking at all the world's desert regions, we find certain general similarities and certain differences. In every desert there are the same problems of securing water, and there is the same lack of permanence where occupance is not closely adjusted to available supplies of water. But, on the other hand, every desert region is unique in many of its most important aspects. Especially is this true with regard to the significance of its location in the world. Some deserts, like those of Iraq and Iran, are of great strategic importance in the conflict of modern great powers outside the desert; some, like the Tarim Basin, are so remote that the modern currents of life pass them by; some, like the Great Basin of the United States, were originally sought because of remoteness, yet inevitably came into the direct line of new settlers. All these things must be analyzed individually for each desert region, and all of them affect the answer to our question concerning the number of people the desert regions can support.

Agriculture in all the world's oases has certain marked peculiarities. As might be expected in the very small spots in the deserts where life is concentrated, all the processes of occupance take on an intensive character. Within the oasis no land can be wasted. Whatever the culture may be, an intensive economy is the rule.[1] The results, however, justify the expenditure of much effort. Probably few agricultural

[1]The economist recognizes land, labor, and capital as the elements of production in our Western culture. Where large amounts of capital or of labor are expended per unit of land, the economy is said to be *intensive*; where the expenditure of labor and capital per unit of land is relatively small, the economy is said to be *extensive*.

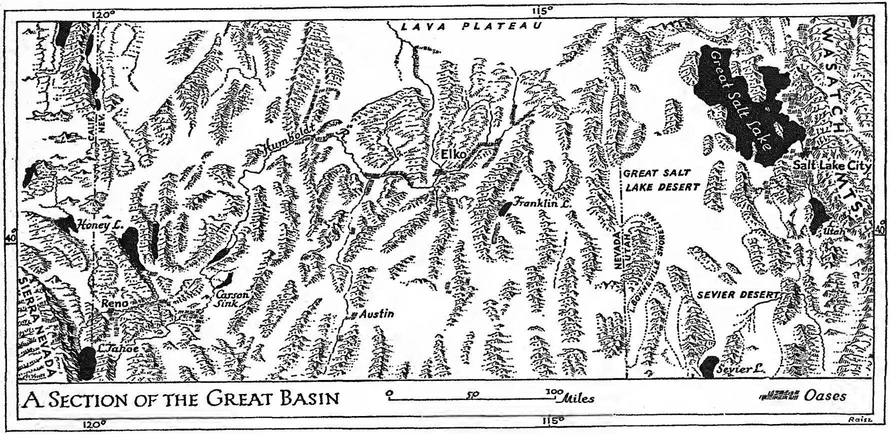


Fig. 13. *A portion of the Great Basin of the United States*

sites in the world bring greater returns per acre for a given amount of labor or capital than do the irrigated lands of the deserts. The abundant sunshine; the ability to apply water to the growing crops when it is needed and in the desired amounts; the richness of the desert soil, especially of the alluvial soils of exotic valleys; the freedom from insect pests and weeds which, in rainy lands, come from uncultivated areas close by—these and other elements contribute to the very large crop yields of the irrigated lands.

While a concentration of activities in the oases is the rule in all cultures, the entry of the Occidental peoples into the deserts has brought one notable change in the agricultural practices. Most of the earlier oasis peoples cultivated chiefly *subsistence* crops; that is, crops which are consumed within the region. One of the distinguishing features of the Occidental culture, however, is the widespread development of commerce, not only in luxury goods, as formerly, but even in the basic necessities of life. The effect of this on desert agriculture is to emphasize the *commercial*, or *money*, crops; that is, the products which are exported from the region. While in many places the same crops have been retained on a greatly expanded basis, in other places an entirely new assortment of crops has been introduced. This new regime means greater material prosperity for some of the desert dwellers; but it also means less economic security, since commercial ventures are in a very important way dependent on events in distant places over which the producer has no control.

The crops which are raised in the oases of the world's deserts do not make up a long list. In the warmer parts of the dry lands, especially in the Sahara and southern Asia, the date is at the present time of chief importance, primarily as a subsistence crop but also, in some of the oases, as a commercial crop. The date palm is limited to the hot deserts because it is very sensitive to cold. Its requirement of very dry air for the ripening and drying of its fruit (both of which processes take place on the tree), together with its need for abundant water, limits this tree to the desert oases. The feathery fronds of the date palm, which stands "with its head in the sun and its feet in the water," make up a characteristic part of the oasis scene. Originally a native, probably, of Arabia, and first cultivated on a large scale in the exotic valleys of the Tigris

Doris Wallace from Black Star

Fig. 14. *A grove of date palms in southern California*

and the Euphrates, this tree is now grown from India across Iran and Arabia to the western Sahara. In the other deserts of the world it is not so common, although its introduction into the Imperial Valley of California about twenty years ago, as a purely commercial crop, has been successful (Fig. 14).

Other subsistence crops are raised along with the date palm in the warmer deserts of the Old World or form the chief support of the oasis dwellers in other lands. Figs, pomegranates, apricots, peaches, and grapes are found in certain more or less specialized areas, especially on the borders of the Mediterranean lands. But the most common and widespread crops include wheat, barley, rice, millet, maize, and beans. Small quantities of cotton, too, should be included in the list of sub-

sistence crops. In some of the cooler deserts alfalfa and other hays are raised during the summer to be fed to domestic animals during the winter season, a type of economy which will be discussed at greater length in a later chapter.

Many of these same crops may be raised for commerce. Dates, for instance, are grown for export in some of the more accessible oases. But by far the most important commercial crops are cotton and sugar. Not that the deserts produce more than a very small proportion of the world's supply of either of these commodities, but in the oases they are the products which furnish the financial returns demanded by the economics of the Occidental peoples. In many oases, but not all, the long-staple varieties of cotton are raised. Since these varieties cannot be grown so successfully in the rainy lands, they command a higher price than the much larger quantities of cotton with shorter fibers. Sugar cane is also raised in many oases, although it cannot be grown in the colder sections, since it requires a year-round freedom from frost. In the United States north of the Colorado River and north of southern California, sugar beets have brought the necessary financial support for the irrigated tracts, protected, however, by tariff barriers against sugars which might be produced more cheaply elsewhere.

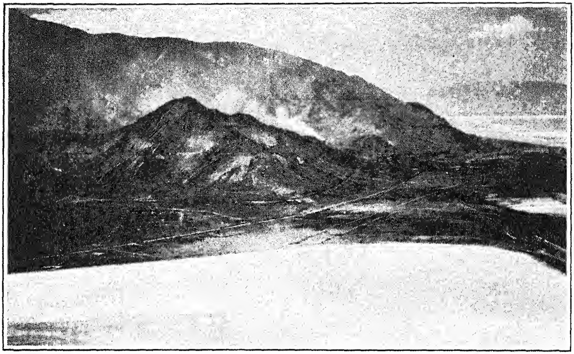
Oasis Towns. The oasis towns of the deserts are the focal points of a highly concentrated life. The arrival in an oasis town is to the desert traveler what the arrival in port is to a sailor. For the desert nomad the oasis furnishes not only a place to exchange his products for other things that he needs but also a place to meet and talk with other people, a place offering many amusements and distractions. From the writings of early Persia we have Omar Khayyám's vivid pictures of the colorful and sophisticated life of the oasis towns, forming the most complete contrast with the loneliness of the vast stretches of desert, in which life is full of difficulties and dangers and yields few distractions. "Every oasis is a Babylon in miniature."

The buildings of the oasis towns differ in detail of architecture from place to place in accordance with the various human cultures, but throughout the world's deserts there are certain general items which are repeated. A very common building material is baked mud brick,

held together with straw. In some few places where stone is available this more substantial material has been used, but wooden houses are very rare. The desert architecture, in places very ornate, seems quite out of keeping with the prevailing building material. The flat roof, in the warmer deserts not uncommonly used for sleeping, is a very widespread form. In the oases of the Moslem world the tall minarets of a mosque usually rise prominently above the general house-level of the town, whereas in the Latin-American deserts the square towers of a Roman Catholic church are the dominating structures.

Ruins. In contrast to the intense life of the present oases are the numerous ruins of once thriving settlements now abandoned. Throughout the world's deserts such ruins have been found, marking the spots where cities once flourished in places now barren and deserted. Some students have explained these signs of decline in population by a gradually increasing aridity which forces the abandonment of settlements because of decreasing water supply. It is a well-established fact that during the glacial period, while ice sheets were formed in cooler and rainier lands, the present desert areas received more rain than they do now. It is supposed that many of the wadi systems, such as those in the western Sahara, are relict forms produced during this period of heavier and more frequent rains. The nitrate salts of the Atacama are thought to have been deposited in the beds of ancient lakes, now long since dried up. The shores of formerly more extensive lakes are clearly visible around the basin of Great Salt Lake in Utah. The body of water which occupied this area in the glacial period is known as Lake Bonneville (Fig. 15). Over long periods of time—much longer than the brief span of written history—it is certain that the climates of the world have varied. However, to show conclusively from statistical data that the climate has changed during historic times is very difficult. There are cycles of wetter years and drier years, but progressive desiccation has been shown beyond reasonable doubt in very few places.

On the other hand, the maintenance of a large oasis is dependent on a strong political authority which enforces co-operation in the use of water and the maintenance of the irrigation works. Weak governments collapse, and with them go the material works of the people,



© Dr. Barnum Brown

FIG. 15. *Terraces of ancient Lake Bonneville*

especially in a land where the price of survival is a high degree of fitness. The ruins of the desert, then, may possibly be explained by the decline of social organization or by wars and conquests. However, it is quite plausible that a cycle of dry years extended over a long enough period of time might result in the crumbling of a government, which, in turn, would make the contest against the desert no longer possible.

The Nomadic Mode of Occupance. In addition to the sedentary modes of desert occupance, with the close attachment of people to the sources of water, the nomadic mode of occupance is found in some dry-land regions. Nomadism in the desert, however, is essentially linked with fleet-footed domestic animals, such as camels and horses. No culture has developed a nomadic occupance of arid lands without these animals. Because no domestic animals of this sort were included in the native cultures of North and South America before the coming of the Europeans, nomadism was not found in the dry lands of the Western Hemisphere. The same is true of Australia and South Africa. Even in the Sahara the Arabs and Berbers did not adopt the nomadic life until the introduction of the dromedary, or single-humped camel,

during the eleventh century after Christ. Before that time Negroid oasis dwellers raised their subsistence crops of grains in blissful isolation. The introduction of the camel and the date palm at about the same time inaugurated a new period in the sequent occupance of the Sahara, which was terminated only by the European conquest eight centuries later.

Nomadism achieves its freest development on the grassy steppes bordering the dry lands—regions which will be described in a later chapter (Group V). Here is found relatively abundant pasturage for the flocks and herds of domestic animals. Those nomads who remain in the dry-land regions are to a certain extent tied to the oases. While they may spend a part of the time wandering in search of pasturage for their animals, they must return to an oasis every now and then as a ship must put in to port. The exchange of animal products (leather, wool, meat, or milk) for the agricultural products of the oases, especially dates, is a characteristic feature of the desert economy.

The latest period in the sequent occupance of the deserts is not aiding the nomadic life. The Europeans have eliminated the caravan trade and have flooded the oasis markets with European-made goods. The nomad finds his mode of existence no longer possible. He is forced to adjust himself to radically different ways of living or to perish.

GROUP II

THE TROPICAL FOREST LANDS

There is no one physical factor which limits settlement in the tropical forest regions as scarcity of water does in the dry lands. The problem of making a living in the deserts is basically a question of maintaining or increasing the supply of water. But in the tropical forest lands the physical conditions which affect human settlement depend to a much larger extent on the attitudes, objectives, and technical abilities of the people themselves. For simple hoe cultivators, tropical living is one thing; for Oriental rice farmers the connections that are built with the resources of the land are quite different. Europeans and Americans, moreover, have to overcome a strong prejudice against these regions, inherited from the writers of antiquity, and this prejudice still colors the attitudes of Occidental people toward settlement in the low latitudes.

The regions of Group II differ from one another with respect to the density and pattern of population. The great area of tropical forest in the Amazon Basin is one of the world's largest areas of very scanty settlement. In contrast, Java is one of the more densely populated parts of the world, and smaller areas of very dense settlement are to be found in parts of the American tropics and in parts of India. The densely populated areas have so many people in them that the regions of Group II as a whole, which include about 15 per cent of the world's land area, are occupied by some 28 per cent of the world's population.

The Land

VEGETATION AND CLIMATE

The regions of Group II are identified by the presence of forest vegetation in which the species of trees are mostly those which cannot withstand low temperatures. In the very wet regions, where there is a superabundance of moisture, the forest is luxuriant; here is found the world's heaviest growth of vegetation, the ***tropical rain forest.*** At the

other extreme, where the climate is subhumid, near the dry margin of forest growth, the characteristic cover is a *tropical scrub forest* mixed with open grasslands. In between, where the climate is humid, is found the *tropical semideciduous forest.*

The Tropical Rain Forest. The tropical rain forest, or *selva,* is the world's most vigorous vegetation growth. Unlike most of the forests which are familiar to mid-latitude people, the selva is composed of an extraordinary variety of species. In one square mile of the island of Trinidad, where a special study of the forest composition was made, nearly three thousand distinct species of trees and plants were identified. It is not unusual to find as many as eighty to a hundred different kinds of trees on a single acre. For the botanist such conditions offer a fascinating and almost inexhaustible field of study; but for the person who wishes to make commercial use of any one kind of tree, this profuse variety is a major handicap, for the individual trees of any one species are usually widely scattered throughout the forest.

The tropical rain forest is an impressive sight for persons brought up in other parts of the world. The monotonous variety of vegetation forms defies detailed description. Within the selva one feels shut in, as in the crypt of a cathedral, for little light is able to reach the forest floor. The individual trees are tall and straight-stemmed, with only a plume of branches and foliage at the top. From the ground one sees only the massive perpendicular trunks which support the thick canopy of leaves overhead where the branches are interlaced in the relentless struggle for sunlight and life. In the gloom below there is little color and little underbrush; but the space between the tree trunks is laced with a network of lianas, some as fine as hairs and others like great knotted ropes.

The remarkable rapidity of vegetation growth is best revealed when a clearing is made. Perhaps the clearing is an abandoned garden plot; perhaps it is the result of the fall of some giant tree which has crushed in its descent all the lesser trees within reach. Through the hole in the leafy covering the sunlight is able to reach the ground. In a very brief time an impenetrable tangle of plants fills the opening. There is a period of fierce struggle to grow upward to the light, which is ended

only when another forest giant has replaced the fallen one, and the fabric of the foliage is whole once more. See Fig. 16.

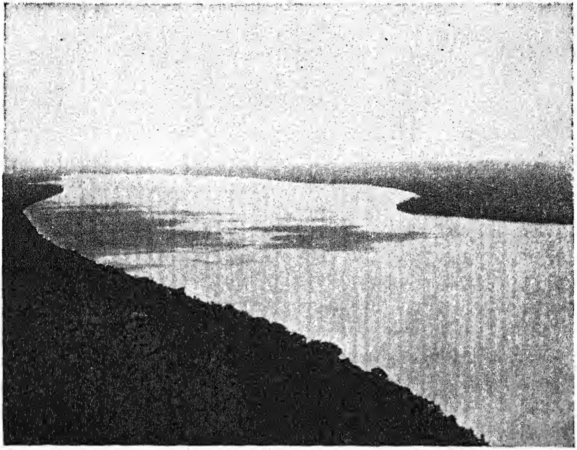
The rhythm of life in the selva is confused. Each individual plant goes through the life processes, producing leaves, flowers, fruits, and seeds in its own period. At all times of the year there are individual trees losing their leaves, or budding new leaves and flowers, or covered with ripened fruit, which, for a short time, attracts a multitude of birds. The forest is evergreen.[1]

The Tropical Semideciduous Forest. Such a vegetation growth as the selva can be supported only by excessive amounts of moisture: where the moisture supply is less abundant, or where a dry season imposes at least a partial rhythm, a lighter forest which is semideciduous in character is the result.

The semideciduous forest is characterized by a more open stand of trees than the selva. Instead of being shut out by an almost unbroken canopy of foliage, as in the selva, here the sunlight penetrates to the ground and supports a dense undergrowth, or *jungle*. Between the rather widely spaced larger trees there is a tangle of smaller plants woven together with vines and creepers, with here and there a thicket of bamboo. Passage through a virgin stand of this forest may actually be more difficult than through a selva on account of the tangle of undergrowth; but because the trees themselves are smaller and spaced farther apart, the clearing of the semideciduous forest is a much easier task than the removal of the rain forest.

Another great difference between this and the rain forest is the existence of a seasonal rhythm. The dry season, which is more pronounced in these regions of lighter forest, imposes a period of rest on the vegetation, just as the winter season imposes a similar period on the forests of the middle latitudes. Many, although not all, of the trees

[1] An evergreen tree is one which does not drop its leaves and stand with bare branches during any season of the year. It may drop one leaf at a time, or even all its leaves at one time, but each leaf is immediately replaced with a new sprout. A forest composed mostly of trees of this sort is described as evergreen. A deciduous tree is one which does lose all its leaves and which stands with bare branches during a season of the year. A forest composed partly of evergreen and partly of deciduous species is described as a semideciduous forest.



Wide World Photos

FIG. 16. *An aerial view of the Brazilian selva near the mouth of the Amazon*

lose their leaves, and the landscape takes on a brownish or grayish tinge. The beginning of the rainy season brings back the dark green of vigorous and thriving vegetation. Throughout the forest the sprouting of new leaves, the budding, the flowering, and the ripening of fruit are synchronized.

The Wet Margin. Where both the tropical rain forest and the tropical semideciduous forest border the ocean along low, shelving coasts, there has developed a peculiar vegetation type which has a number of unique characteristics. This is the mangrove forest—not distinguished from the other kinds of tropical forest on the plates because it occurs only in a fringe along the coast which is usually too narrow to show on the maps. The mangrove consists of only one kind of tree of the genus *Rhizophora.* On the shores of tidal swamps where the water is brackish there is a dense tangle of evergreen trees which grow some

15 or 20 feet in height, with spreading bushy branches and numerous aerial roots. The bark is reddish in color and useful as an astringent; the leaves are oblong and glossy; the pale yellow flowers and conical berrylike fruit appear at all times of the year with no seasonal rhythm. New trees develop from seeds which germinate in the air and which are attached to the root system of the parent trees. The result is a tangle of bushy forest which is all but impenetrable. The mangrove fringe actually makes long stretches of most tropical coasts unapproachable; many established ports owe their location to natural breaks in the mangrove large enough to permit the entrance of ships and the construction of roads to the higher country behind the coast.

The Tropical Scrub Forest. Rainfall effectiveness in the tropical lands is relatively low, for the high temperatures result in a very rapid evaporation. Even with fairly high annual rainfalls there are many parts of the tropical forest lands which support only a scrub forest. In some places the low trees are protected by thorns—a vegetation type known as the *thorn forest* (or *caatinga*, to use the Brazilian term). The trees are small in diameter and spaced far enough apart so that the ground is little shaded. The forest floor is usually grass-covered, giving the landscape the appearance of a poorly kept orchard. All such scrub forests have a definite seasonal rhythm in harmony with the rains. During the growing season the trees are a mass of foliage and flowers of brilliant coloring, but during the dry season the leaves fall to the ground and the branches are bare.

The scrub forest does not have so great a variety of species as either the selva or the semideciduous forest. The kinds of trees which compose it are remarkably similar in the different continents. In both Africa and South America, for instance, the trees belong to the family *Mimosaceae*; in Africa they are of the genus *Acacia*; and in South America, of the genus *Mimosa*. It would be difficult for a person not trained in botany to distinguish between the African scrub forests and those of South America.

The Dry Margin of the Tropical Forests. The dry margin of the tropical forests is not a sharp one. Excepting where man has inter-

vened, there is usually a wide zone of mixed forest and grassland or savanna. The tropical scrub forest, in fact, is a vegetation type which is generally found in places of lower rainfall effectiveness than are the tall grass savannas. Patches of scrub forest in some places actually border the regions of Group I where bare ground distinguishes the dry lands from bordering regions. This occurrence of scrub forests on the dry-land border may be seen in India, in the Chaco of northern Argentina, along the Gulf coast of Mexico just south of the Rio Grande, and in other smaller areas (Plates 10, 12, and 18).

On the dry side of the forest regions it is not uncommon to find scrub forests and savannas intermingled. From a forest with grassy openings or with grass on the forest floor, one passes by degrees to a grassland covered with scattered trees or interrupted here and there by thickets. In almost all the world's savannas the floodplains of the rivers are followed by ribbons of tall semideciduous forest. Such river-bank forests are known as *galerias* (from the Italian word for tunnel) because the smaller streams, at least, may flow under a complete arch of foliage. As a result of such a mixture of forest and grassland, the actual mapping of these two kinds of country is in many cases very difficult, for it becomes a matter of separating two landscapes which, where they meet, are very much alike. A few more trees per acre and the country is mapped as a scrub forest; a slightly greater spacing of the trees, and the country is mapped as a savanna.

Human Population. To judge by the present distribution of people in the tropical forest lands, there is a marked preference for the regions of moderate humidity covered by the semideciduous forests. The tropical rain forests, with some important exceptions, are thinly populated. The exceptions are mostly in the Asiatic low latitudes where a rice-growing people have established themselves with great density on the floodplains of the rivers, and on the terraced lower slopes of hills or mountains where rainfall is heavy. The scrub forests and savannas seem to offer the poorest conditions for settlement, for only in a few places have these subhumid regions been occupied by farmers. Irrigation must usually be practiced; yet in these regions, where there is commonly a season of heavy rains, provision must also be made for

drainage. Most of the areas of major settlement in the regions of Group II are in the semideciduous forests.

Native Animals of the Tropical Forests. The native wild animals of the tropical forests differ considerably on the different continents. In the South American forests there is a notable paucity of large ground animals, although there are many different kinds of birds, monkeys, and snakes which inhabit the dense foliage far above the ground. Underneath, in the deep shadows, close observation reveals a multitude of insects, such as ants and spiders. The termites, or white ants, are particularly destructive of any organic matter which chances to fall on the ground. Whole villages have been abandoned in the face of an invasion of ants.

These various kinds of animals are also represented in the tropical forests of the other continents, but in these other regions they are a part of a larger and more abundant fauna. Africa, especially, is famous for its animal population. While most of the African animals really belong to the savannas, they penetrate the relatively small areas of forest in central Africa and so must be included in a discussion of Group II. A great many different kinds of herbivora feed on the savanna grasses during the rainy season or cluster about the water holes during the dry season. This fauna includes such fleet-footed types as the antelope, the zebra, and the giraffe. In the Congo Basin are found the elephant, the okapi, the buffalo, and the wart hog, and, in the rivers, the hippopotamus and the crocodile. The actual distribution of some of these animals is related to the particular types of vegetation which furnish them food. In southern Africa, for instance, the giraffes are found only in areas where the acacia trees grow. Most of these plant-eating animals are preyed upon by carnivora, and the distribution of the latter usually agrees closely with the distribution of the species they pursue. The lions, for example, in parts of Africa are largely confined to regions inhabited by the gazelles.[1] In the semideciduous forests of southeastern Asia the fauna includes the elephant, the buffalo, and the tiger (Fig. 17).

The insect life of the tropical forests on all the continents is abundant, especially in the transitional areas between the forests and the

[1]E. L. Trouessart, *La Distribution géographique des animaux* (Paris, 1922), p. 79.

Ewing Galloway

FIG. 17. *A tiger at a waterhole in Siam*

grasslands. Because many of the insects are carriers of disease they form a serious obstacle to human occupance or to the introduction of domestic animals not immune to these diseases. The mosquito is the most common and dangerous; but there are many others, such as the famous tsetse fly of Africa, which carries the dreaded sleeping sickness.

Weather and Climate in the Tropical Forests. One of the parts of the world where weather and climate come close to meaning the same thing is in the wetter parts of the tropical forest regions. As these terms are properly defined, weather is the state of the atmosphere at any given time, whereas climate is the average of weather at a particular place and for a particular period. But in the tropical rain forest, at least, the day-to-day and month-to-month weather is so remarkably uniform that

the two words seem to have almost the same meaning. The weather is so similar from day to day that the common small talk of mid-latitude peoples is difficult to carry on, and appointments are made in terms of the showers and alternating periods of sunshine.

These regions are characterized by monotonously high temperatures. The common belief that the equatorial regions are unbearably hot is quite incorrect. The highest temperatures in the world have been observed, as we have seen, in the deserts. Temperatures in summer in the lower middle latitudes (in the Mississippi Valley, or the Ganges Valley, or the Argentine Chaco) are much higher than any which are ever experienced in the low latitudes near the equator. Belém, near the mouth of the Amazon, for example, rarely, if ever, has a temperature over 100°. The highest temperature recorded at a place farther up the Amazon was 96.3°. Yet between the average of the coldest and warmest months there is a range of only about 3°. It often has been said that "night is the winter of the tropics," for the diurnal range is actually greater than the annual range. At Belém the temperatures at night drop some 15° below those of the hottest part of the day. In such a climate the terms *summer* and *winter* are misleading, for there is really nothing which corresponds to our mid-latitude concept of winter. The average annual temperatures are between 70° and 80°—few are higher than that. Only rarely are very high temperatures experienced, and rarely do the temperatures drop below 60°. At Belém the average highest and lowest temperatures of the year are 91.4° and 68.0° respectively.

The *heat equator* is the line connecting the places of the world which have the highest average annual temperatures. It passes along the northern coast of South America and along the Guinea Coast of Africa —lying some five to ten degrees north of the geographic equator in these continents. It runs south of the geographic equator only in northern Australia.

Temperatures such as are recorded in the rainy tropics would be quite comfortable were it not for the rains and the humidity. In the tropical rain forests the humidity is especially high. Even though the year in all but a few parts of the tropics is divided into a rainy season and a dry season (instead of summer and winter), the dry season in

the selva is actually only a season of less rain. On a characteristic day the sun rises in a clear sky. Fog is sometimes hanging in the low valleys, but this speedily rises in curling wisps of vapor as the land is heated by the sun's rays. Soon puffy cumulus clouds appear, before long covering a large part of the sky. A light shower may occur, often as early as eight or nine o'clock in the morning. This is followed by a period of brilliant sunshine and then by another shower. Showers and sunshine alternate in this way throughout the day, the former becoming more severe and of longer duration as the day progresses. About four in the afternoon a very heavy shower occurs—a deluge of rain accompanied by little wind. The storm, at first torrential, later settles down to a steady rain which continues into the evening. It is a characteristic remembrance of the rainy tropics: the beat of rain on an iron roof, the monotonous splash as the water runs off onto the ground, and the sticky wetness that penetrates everything and leaves one soaked with perspiration. Well into the night the rain gradually ceases and is succeeded by a deep silence, relieved only by the dripping of water from the soaking foliage and by the hum of the dreaded mosquito. Without the cooling winds of an exposed coast the tropical rainy lands may become quite uncomfortable.

But there are many parts of the tropical forest lands where the climate is not at all like this. Especially on the east coasts of the continents and islands, strong easterly winds increase the evaporation and in part compensate for high humidity. Where the graceful coconut palms toss their heads in the steady, strong breeze from the water and where the buildings are open to the moving air, life can be untroubled by the stimulating effect of variable weather such as is experienced in the middle latitudes. Here, in a veritable paradise, men may relax if they know how to do so.

The paradise is a dangerous one, however. It is a fact that where the human body is not subject to the necessity for making adjustments to frequent changes in temperature and humidity, it eventually loses the capacity for such adjustment. The "chills" which are described as dangerous for health in almost all handbooks on tropical living can result from a drop of only a few degrees in temperature. Long residence in the extremely monotonous climates of parts of the low lati-

tudes can, apparently, produce bad physiological effects on the human system. It is the monotony, rather than the high temperature, which is bad; and it is just as bad for the people of one race as for those of another.

Wartime studies of the effect of high temperature and high humidity on the human system have demonstrated that there are certain maximum combinations of heat and humidity beyond which the human body cannot survive. Heatstroke and death can result where the air is saturated with moisture and where the temperature reaches 85°. Where the air contains 70 per cent of all the moisture it can carry (in other words, where the relative humidity is 70 per cent) the danger point is reached when the temperature is 95°. These combinations of heat and humidity are actually experienced occasionally in nature, but no place on earth has average conditions of this sort. The fact is, too, that the places where high heat and high humidity occur together most often are generally not in the rainy tropics. The part of the world in which human life is most difficult in terms of these weather elements is along the shores of the Red Sea, in a region which receives very scanty rainfall.

Distribution of the Tropical Forest Lands. The general arrangement of the tropical forest lands in the world can be described quite simply. They occupy a belt somewhat less than 20° wide on either side of the equator and extend poleward along the eastern sides of the continents to the margins of the low latitudes. Even more than in the case of the dry lands, this general position is modified in detail on each of the continents. As a result of the disposition of the land masses, however, there are three chief areas of occurrence: in the Americas, in Africa, and in Asia-Australia.

The largest single area of selva in the world is in the Amazon Basin and parts of the Guianas (Plate 12). The westward extension of this forest is limited by the Andes, and only a narrow fringe of selva is found along the Pacific Ocean in Ecuador and Colombia. On the east coast of South America the selva is found as far south as latitude 25° S.; and a semideciduous forest extends somewhat farther south in the Paraná Valley of eastern Paraguay. Most of the eastern margin

of the Brazilian Highlands has a semideciduous forest. In the northeastern part of Brazil, however, both the selva and the semideciduous forests are interrupted by a tropical scrub forest—a caatinga; and between the scrub forest and the Amazon selva there is a narrow belt of savanna. A considerable area of scrub forest also occupies the Gran Chaco, in the upper Paraná Valley. North of the equator the tropical forests are found throughout the West Indies as far north as southern Florida, and they occupy the lowlands on the eastern side of Central America and Mexico almost as far north as the mouth of the Rio Grande, and on the western side to about 20° N.

In Africa selvas and semideciduous forests occupy parts of the Congo Basin and parts of the south-facing Guinea Coast. The Congo forests, in part because of the higher altitude of this region, are probably not so luxuriant as the analogous forests of South America. In southern Africa, separated from the Congo forest by a belt of savanna, there is a large area of scrub forest. The east coast of Africa has only a narrow fringe of tropical forest.

Selvas and semideciduous forests occupy the lowland areas of the East Indies and many of the small scattered islands of the southern Pacific. Scrub forests and semideciduous forests fringe northern and northeastern Australia. Semideciduous forests are extensive on the eastern coast of Indo-China and in the great river valleys of southeastern Asia—the Mekong, the Menam, the Salween, the Irrawaddy, and the delta of the Ganges-Brahmaputra. The lowlands of Ceylon and the Malabar Coast of India are occupied by selvas. The Deccan Plateau and most of the Ganges and upper Indus valleys are covered by scrub forest, which in the northwest extends beyond latitude 30° N.

Winds and Rainfall of the Low Latitudes. This distribution of the various types of tropical forests is related to the basic facts of rainfall effectiveness. As we have seen in the previous discussion of the world's dry lands, it is important to know not only the total amount of rainfall each year, but also the balance of other factors that determine how much of the rainfall is effective. Where temperatures are always high, evaporation is rapid. As a result, a low effective rainfall is revealed in

the natural cover of vegetation at places where the average annual rainfall is still high—high, that is, as measured by middle-latitude experience. In the central part of the United States, for example, average annual rainfall between 30 and 40 inches can be considered as moderate—certainly adequate for unirrigated crops or for a continuous forest cover. But in the low latitudes, where temperatures throughout the year are high, an annual rainfall below 40 inches, even if well distributed through the year, can support only a scrub forest or a poor semideciduous forest.

The occurrence of generally heavy rainfall on low-latitude east coasts is related to the world's wind systems and the world's ocean currents. Looking at the globe as a whole, we can see that there are five great whirls of air: two in the Northern Hemisphere and three in the Southern Hemisphere (Plates 26a and 26b). Those in the north circulate in a clockwise direction; those in the south circulate in a counterclockwise direction. In each case the whirl of air is centered at about latitude 30° N. and S., and over the eastern part of the ocean basin. The whirl is so large that it covers almost all the oceans and a considerable part of the continental margins. These components of the general circulation of the atmosphere are called the *oceanic whirls.* The physical reasons which determine their position and strength are presented in Appendix B, sections 20 and 21.

In the low latitudes, over the oceans, the winds are moving generally from east to west—from the northeast in the Northern Hemisphere and from the southeast in the Southern Hemisphere. These low-latitude winds are known as the *trade winds.* As the oceanic whirls approach the eastern margins of the continents in higher low latitudes, the air follows a curving path to the right in the Northern Hemisphere and to the left in the Southern Hemisphere. Along the equator, where the two whirls converge, there is between them a belt of shifting winds and calms which is known as the *doldrum belt.*

The ocean currents move in harmony with the prevailing winds. In the Northern Hemisphere ocean basins the water circulates generally in a clockwise direction, and in the Southern Hemisphere ocean basins it circulates in a counterclockwise direction. Where the two currents converge near the equator there is an equatorial countercurrent

which moves back from west to east.[1] These ocean currents are shown on Plate 23, which also distinguishes warm and cold water. From this map it can be seen that the continental east coasts are bathed by warm water, and, similarly, the west coasts for some ten degrees on either side of the equator are warm. But the continental west coasts between about 15° and 35° N. and S. are bathed by cold water.

Rain is produced only where air which has picked up a large amount of water vapor is forced to rise and cool. The major source of water vapor is warm ocean water, for here evaporation from the water surface is rapid—very much more so than over cold water. Air is forced to rise when air masses converge, as in the doldrum belt along the equator, on the margins of continents where the wind is onshore, or on the windward slopes of mountains. For this reason the eastern coasts of low-latitude continents where air is moving strongly onshore from across warm ocean water are especially rainy (Plate 7).

The Monsoons. There are other places where the combination of wind direction and ocean current produces heavy rain. As is explained in Appendix B, the basic cause of horizontal air movement is difference in temperature. Air moves from relatively cool places to relatively warm places, and, except close to the equator, is deflected from a straight course by the earth's rotation—to the right in the Northern Hemisphere and to the left in the Southern Hemisphere. Where large land masses are so arranged that there is a stretch of coast facing toward the equator within the low latitudes, the land (most of which, under these circumstances, lies in the middle latitudes) becomes much hotter than the water in summer and much colder than the water in winter. The result is a seasonal shift in wind direction: from the cooler water to the warmer land in summer, and from the cooler land to the warmer water in winter. Winds which blow steadily for six months in one direction and for the other six months in the opposite direction are known as *monsoons*. They are developed strongly on all the equatorward-facing coasts in the low latitudes: notably along the coast of southern

[1]It is customary to name a wind by the direction from which it comes, but to name an ocean current by the direction toward which it flows. Thus an east wind is one which moves from east to west; and an easterly ocean current is one which moves from west to east.

Asia and northern Australia, the Guinea Coast of Africa, and the Gulf coast of the United States; and to a lesser or partial extent along the Pacific coast of Central America, and the Atlantic coast of South America from the equator to Cape São Roque in Brazil.

In regions dominated by the monsoons there are heavy rains when the winds are onshore, and very little rain when the wind is offshore. But in many places the rains of the rainy season are so heavy that a forest vegetation—usually a semideciduous forest—can survive the dry season. Throughout the low latitudes between southern Asia and northern Australia the prevailing winds shift seasonally, bringing strongly marked rainy and dry seasons which depend on the orientation of the land with reference to the seasonal winds (compare Plate 7 and Plates 25, 26, and 27). Thus northwestern Java gets its heaviest rain when the winds are moving out of Asia and toward Australia, in the Southern Hemisphere summer; and southern Java gets its maximum rain at the opposite time of the year, in the Northern Hemisphere summer.

The two weather stations in the world which bid for the distinction of receiving the highest average annual rainfall are both located on windward mountain slopes where strong onshore winds come heavily laden with moisture picked up from warm water. The present high record is held by a station on the northeastern slopes of the mountainous island of Kauai, the northernmost of the Hawaiian group, where an average of 476 inches a year is reported, fairly evenly distributed throughout the year. The second rainiest place on earth is Cherrapunji, located in the hills of Assam, a little north of Calcutta, where an average of 457 inches a year is reported. This place, however, receives most of its rain during the onshore monsoon of summer. July averages 109 inches of rain; but December averages only 0.2 inch (see the climatic data for selected stations in Appendix E).

SURFACE FEATURES

The surface features of the humid lands of the world are quite different from those of the dry lands. There are, to be sure, the same kinds of geologic structures and rocks in both; but the manner in

which the rock structures have been sculptured by the processes of erosion in the rainy lands is very different from that in the dry lands. Under rainy tropical conditions, where there is a dense cover of forest vegetation, the rock surfaces are usually decomposed to great depths by chemical action. The mantle of loose earth which covers the solid rock is molded into rounded forms quite different from the angular forms of the deserts. Rivers find their ways to the ocean and carry with them large quantities of alluvium. Where structural basins occur, which in the dry lands might form bolsons, they are filled with water. The rift depressions of East Africa (Plate 13), which are filled with fresh-water lakes, are very similar in geologic structure to such dry-land rifts as Death Valley in California or the Dead Sea depression of Palestine.

Surface Configuration. The larger surface features which stand out when we examine continental maps—and which are comparable to such features as hamadas, ergs, or mountains and bolsons in the dry lands—are four in number: plains, plateaus, hilly uplands, and low mountains. The high mountains, which in some places closely border the regions of this group, are included in Group VIII.

The words used to describe these four major surface features are all common in non-technical language. The words used by geographers to describe the surface features of the dry lands are strange to most people who speak English, but every such person thinks he knows what is meant by the words plain, plateau, hill, or mountain. Yet the actual use of these words in naming the features of the land suggests that in the popular vocabulary there is no very careful definition of them. The Turtle Mountains of North Dakota, for example, are only a few hundred feet high above the plain upon which they stand; they are really a part of the plain, but the local people call them mountains. If they are to be called mountains, then the Berkshire Hills of Massachusetts would certainly have to be renamed. To use these words in a more exact sense in geography, we must define them more carefully than does the dictionary; but in so doing we must be prepared to find that features which are popularly called mountains are really plains, that features called plateaus are really hills, or that features called hills are

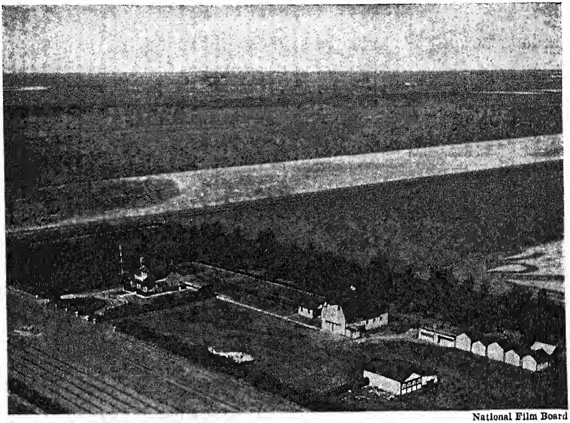


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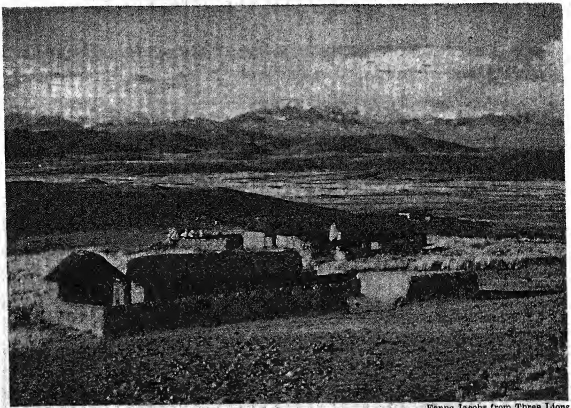
FIG. 18. *A stretch of the plains in Saskatchewan, Canada*



Fenno Jacobs from Three Lions

FIG. 19. *Looking across the Plateau of Bolivia toward snow-capped peaks of the Andes*

really plateaus. We must be ready to distinguish between proper names and the more or less technical geographic terms which describe them.

These four categories of surface features may be given somewhat more accurate definition as follows. A *plain* is an area of low relief,[1] generally less than five hundred feet. It is low-lying with reference to bordering areas, and is usually, but not in every case, low in altitude. A *plateau* stands distinctly above bordering areas, at least on one side; and it has a large part of its total surface at or near the summit level. Its local relief may be very great in cases where it is cut by canyons; or it may have as small a local relief as a plain, from which it differs in such a case only because of its position with reference to bordering areas. A *hilly upland* has more than five hundred feet of local relief and has a relatively small proportion of its surface at or near the summit level. *Low mountains* have more than a thousand feet of local relief, and, like hilly lands, have a relatively small proportion of the surface near the summit level. High mountains, which are given further definition in the chapter dealing with Group VIII, generally have a local relief in excess of three thousand feet.

These distinctions between the major surface features of rainy lands are, of course, arbitrary, and in many places are difficult to apply. An area which fulfills the definition of a plateau on one side may resemble a plain on the other side; or a hilly upland may seem conspicuous enough to be called a mountain from one viewpoint. The name actually applied is more or less a matter of custom. For example, the Congo Basin might be classified as a plateau because it drops steeply toward the sea; or as a plain because it is almost entirely surrounded by higher land and because its local relief is less than five hundred feet. As a matter of fact, it is generally described as a plain.

[1]The relief of an area is the difference in elevation between the highest and lowest points. Relief is different from altitude, which is usually measured from mean sea level. There may be surfaces of very slight local relief standing at very high altitudes—for example, the Plateau of Tibet; or there may be very steep slopes and great differences of local relief within an area which lies below sea level—as on the slopes of Death Valley. Local relief may be defined as difference of elevation within any selected area of restricted size. See V. C. Finch and G. T. Trewartha, *Elements of Geography*, New York, 1936, pp. 319 and 321.

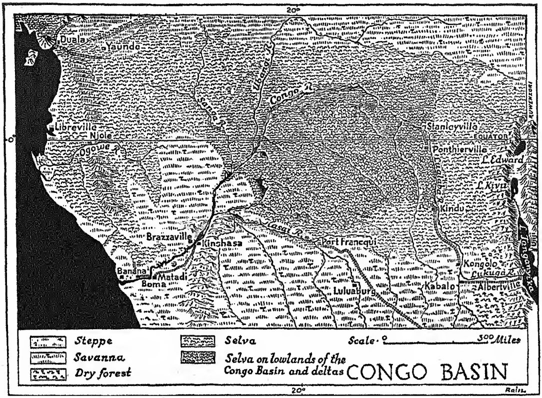


FIG. 20. *Surface configuration and vegetation cover of the Congo Basin and adjoining areas.* (Vegetation after Schantz and Marbut)

Distribution of Surface Features. The surface configuration of the several areas of Group II is presented on Plates 9–19. The two great plains regions in this group are found in the Amazon Basin of South America and in the Congo Basin of Africa (Figs. 20 and 22). However, although these two regions resemble each other in their relatively low relief, they are otherwise quite different. The Amazon drains a region of low altitude. The main stream is navigable for ocean boats for thousands of miles inland, almost to the base of the Andes. The Congo, on the other hand, drains a plain which lies over a thousand feet above sea level. The whole continent of Africa, in fact, may be thought of as a huge plateau with steeply scarped sides. The Congo descends over this escarpment in a series of falls and rapids. It is navigable for river steamers above the falls, but ocean boats can do no more than enter its mouth. Elsewhere throughout the regions of Group II small coastal or river lowlands exist, but none are on the scale of the Amazon and the Congo.

The plateaus, hilly uplands, and low mountains of this group are most extensive in Africa and South America. The East African Pla-

teau follows the eastern coast of Africa southward from Ethiopia, leaving only narrow patches of coastal lowlands along the water. In a few places the plateau is surmounted by mountains or broken by great rift valleys. The highlands of Guiana and Brazil are somewhat more complicated. They are composed of a mixture of hilly upland, plateau, and low mountains. From northeastern Brazil far to the south the highland faces the coast with a steep escarpment which rises between two and three thousand feet above sea level. The peninsular part of India is also composed of a mixture of plateaus, hilly uplands, and low mountains, and there is even a small area of high mountains along the southwest side (Fig. 26). South of Bombay the narrow fringe of coastal plain is known as the Malabar Coast. Northern Australia and parts of New Guinea and Borneo are also hilly.

Most parts of the Asiatic tropics, however, are made up of great river lowlands set in the midst of ranges of high or low mountains. There are extensive plains formed by the alluvial deposits along the lower courses of the Ganges-Brahmaputra, the Irrawaddy, the Menam, and the Mekong (Fig. 23). There are relatively wide plains along the northern sides of Sumatra and Java and in southern Borneo. But elsewhere there are only narrow delta plains where the rivers come down from the mountains. Similar conditions exist in Central America, the West Indies, and in the islands of the southwest Pacific.

LANDFORMS, DRAINAGE, AND SOILS

The detailed surface features, or landforms, of Group II, which are the surface forms visible when studied on large-scale topographic maps, are those which are developed under a forest cover where rainfall is abundant. Wherever there is land standing above sea level the rivers are doing the work of wearing it down, carrying its loose rock particles downhill and eventually to the lowlands or into the sea. Under a dense forest cover, however, fairly steep slopes can remain protected from rapid erosion by the tangle of roots. When such slopes are cleared by man the results are often disastrous, for, with the protection of the forest removed, deep gullies speedily develop unless special measures, such as terracing, are taken to guard against this kind of destruction.

When the streams descending from mountains or uplands reach the plains they begin to deposit silt and gravel, building alluvial plains and deltas. The rivers usually wind back and forth, or meander, across the plains, only in time of high water spilling out of their channels and inundating large areas. The land across which a river meanders and which is subject to flooding at high water is called the *floodplain*. It is sharply set off from the rest of the plain, which is not subject to flooding, by steep valley bluffs. Along the lower Amazon (Fig. 22) the floodplain is some fifty or sixty miles wide, and the valley bluffs which border it stand some two hundred feet above the river (see Appendix C, section 10). Only on the floodplains or in lagoons along low coasts are there extensive swampy areas. The evaporation is too rapid to permit the presence of standing water at the surface for any long period of time except when it is actually raining.

In the wet parts of the world a certain proportion of the water which falls on the surface sinks into the ground. We have seen that in the dry lands only a small part of the rainfall actually gets into the soil where it is effective in the support of plants. In regions which are frozen for part of the year, the amount of water sinking into the ground is reduced. But in the rainy tropics the ground is never frozen; water sinks into it whenever rain falls. This percolating water is one of the factors which determines the character of the soil.

Water descending through the loose rock fragments which mantle the surface changes the soil in two ways, physically and chemically. In the first place (the physical change) it carries down with it the smaller soil particles. The upper layer of the soil becomes coarser and coarser; and the fine particles are deposited in a layer at some distance below the surface which eventually becomes a hard pan of clay. This process is called *eluviation*. The longer it goes on the poorer the surface soil becomes for shallow-rooted crops.

The second change produced by percolating water is a chemical one. The minerals which can be dissolved in the water are, little by little, carried away in solution, leaving in the upper soil layers only the relatively insoluble minerals, the ones least valuable for plant food. Like any chemical process, solution goes on more rapidly at higher temperatures than at lower temperatures. This process is called *leaching*,

and, as in the case of eluviation, the longer it goes on the poorer the soil becomes. In the rainy tropics the minerals least apt to be dissolved are the iron and aluminum compounds. On level land which is not subject to flooding and so to the deposition of new alluvial material, the soil which develops is a yellowish or reddish sandy material known as a *laterite*. Outside the floodplains, other level lands of these regions normally have soils of low fertility for shallow-rooted crops. That tropical soils are fertile is one of the common misconceptions about the low latitudes which needs to be corrected.

There is a third soil-forming process which contributes also to the characteristic infertility of tropical soils. This is called *humus accumulation*. Organic matter falling on the forest floor is rapidly attacked by bacteria and decomposed. In cooler and less rainy regions bacterial action is slow, and a layer of dark-colored or black humus is found under the fallen leaves. But in the rainy tropics temperatures are high and bacterial action is very rapid. Humus can accumulate only in a very thin layer and in certain spots. When the forest is cleared the humus is quickly destroyed. This is another element of infertility in these soils in terms of the common food plants.

The Occupance

The conquest of these tropical lands by man is far from complete. In a few parts of the world the original landscape has been permanently and radically transformed by human settlement, but in each case this has been accomplished only by large numbers of settlers. Where such settlement has been made the population today is very dense—as in the Oriental rice lands. But the forest does not yield easily to small numbers of pioneers, nor to the more or less temporary activities of Occidental plantation owners. Certain people of simple farming culture have occupied parts of the tropical forest lands with moderate density, but the clearings they make are constantly threatened by the closely crowding cover of vegetation and are usually not permanent. Large areas of Group II are occupied by less than one person per square mile.

The settlement pattern within this group suggests that the regions most favorable for agricultural settlement are those which are covered

by semideciduous forests. Apparently the obstacles to settlement found in the grasslands and scrub forests on the one hand or in the selvas on the other have, in most places, discouraged permanent occupance. Not only are the semideciduous forests easier to clear for a people armed only with simple tools, but the soils in these forests are less leached and eluviated than those found under the very rainy conditions which produce a selva. The soils in still drier regions are probably better even than those under the semideciduous forest, but in such regions farming is made difficult by the need for drainage and irrigation.

In these tropical regions, as in the dry lands previously described, the culture determines the way in which people occupy the territory. Besides the Occidental culture, which has in relatively recent times extended its influence into the different parts of this group, there is a considerable variety of "native" cultures. The word "native" is used here to describe non-Occidental cultures, although this use is admittedly somewhat loose, since many of the so-called native cultures were imposed by conquest upon still earlier native peoples, who themselves no doubt entered the region originally from outside. These cultures, which occupied the tropical forest lands before the advent of the Europeans and Americans, range from quite simple, primitive types to the advanced and highly elaborate types of India and Java. Since, unlike the deserts, very few parts of these regions are uninhabitable, the various cultures have a wider freedom to develop patterns of occupance peculiar to themselves. Although in the dry lands all cultures alike are tied to the sources of water, in the tropical forest lands some peoples concentrate permanently on the hot and well-watered alluvial plains, others concentrate on the cooler highlands not too remote from access to the outer world, and still others move about from place to place so that the arrangement of their settlement at any one time is a temporary and fluid one.

OCCUPANCE BY MIGRATORY FARMERS

There are many resources in the tropical forest regions on which a primitive people with few and simple wants can support themselves. Edible fruits and nuts are available for those who know how to find

Nelson from Ewing Galloway

FIG. 21. *A native hut in a clearing in the Central American jungle*

them. The rivers abound in fish and turtles, and many of the primitive tribes make regular seasonal migrations to the fishing places.[1] Sea-fishing is of great importance among those who occupy islands or coastal lands. Many of the rain forests are poor in edible land animals, so that hunting is generally limited to the search for a few kinds of birds and monkeys. The lighter forests, however, especially those of Africa, have a more varied animal life, as we have seen. Some of the primitive tribes of the Congo, such as the Pygmies, are specialized hunters, carrying on no agriculture, but attaching themselves to the outskirts of agricultural settlements and exchanging meat for agricultural products.

In most of these regions the hunting, fishing, and collecting are

[1] J. Brunhes, study of the "Fang Tribes" of Africa, in *Human Geography* (Chicago, 1920), pp. 350–368.

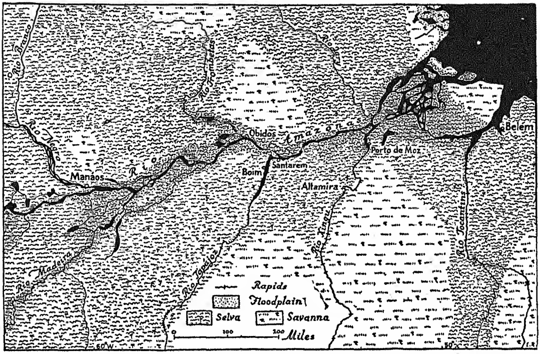


FIG. 22. *A part of the lower Amazon Basin.* (Vegetation after Denis)

supplemented by crop cultivation. Imagine, however, the difficulties which stand in the way of a people whose culture includes the use of only a few implements! The removal of the large trees of the forest is a task which requires more effort than the results make worth while. In the Amazon forest the clearings for agriculture are made by removing and burning only the smaller trees. Crops are planted among the charred trunks in the partial shade of the forest giants, which are not touched. Such haphazard agriculture is a purely temporary affair; the confusion of weeds which soon springs up among the crops makes it easier to clear a new area elsewhere than to attempt a more permanent cultivation. Crops are harvested from a jungle, and the tribe moves on. This is known as *migratory agriculture.*

Other native peoples, however, practice a more elaborate form of migratory agriculture. With the aid of better tools the forest is entirely cleared, except for a few species of trees which bear edible fruits or nuts and are too valuable to be destroyed. In the first year after clearing, these native gardens support an extraordinary wealth of plants. Towering overhead are the fruit or nut trees left over from the forest. Below, the tallest planted crop is the banana. Below this is a haphazard

confusion of manioc bushes,[1] maize, sugar cane, dry-field rice, peanuts, and tobacco. Finally, on the ground are such crops as yams, beans, eggplants, tomatoes, and many others of our common vegetables, which here grow to large sizes. Although these gardens are inefficient and unsystematic in appearance, more actual food per acre is probably produced in them than in gardens planted by any other agricultural method.

Such productivity, however, cannot be maintained. In a year or so, after the crops of maize, rice, and vegetables are harvested, the bananas and manioc become so thick that no other crops can survive. The manioc continues productive for as long as four or five years, after which the bushes are cleared away and the bananas and fruit trees alone occupy the land. The banana plants overrun the clearing, intertwined with creepers, vines, and a profusion of other plants. Gradually the former garden takes on the aspect of a jungle. The clearing of new land presents fewer difficulties than the removal of this second growth.

As long as migratory agriculture can be practiced over a wide extent of territory by a relatively small number of people, the essential infertility of the soil may not become important, for only virgin soils are used. In areas of somewhat denser population, on the contrary, the decline of crop yields may become serious. When all the territory in the neighborhood of a village has been worked over and abandoned, either the village itself has to be moved to a new site or else previously worked land must be cleared for a second time. The abandonment of the village is a simple matter, for the houses are of light construction and are built of readily available materials. But the repeated use of the land for the production of such heavy crop loads rapidly exhausts the small amount of natural fertility in the soil. Not only are the yields much diminished, but on the abandoned clearings the coarse savanna grasses begin to come in to the exclusion of the other vegetation types which can no longer be supported. For a people armed only with the hoe, the removal of grass is even more difficult than the removal of the forest. Eventually the community is faced with starvation and may break up into several streams of migration, as the Mayas of Yucatan

[1]Manioc is a root crop which continues to yield for a number of years after it is first planted. From it is derived what we know as tapioca. This crop is also called mandioca or cassava.

are thought to have done. The abandoned clearings now form open grassy patches in the midst of the forest. To this kind of economy the Germans give the expressive term *raubwirtschaft*, or robber economy, because it makes use of the resources available in nature in such a way as to destroy them.

OCCUPANCE OF THE RICE LANDS

The cultivation of rice is one of the distinguishing traits of several Oriental cultures. The subtropical margin of the Asiatic low latitudes is probably the native home of the rice plant. While at the present time this crop is concentrated chiefly in the mid-latitude regions with mild winters (which we shall describe in a later chapter), it is also found on a large scale in the neighboring parts of the tropical forest lands. The Eastern cultures are in numerous ways built up around rice; for not only does this crop furnish a very large part of the food supply, but the labor of producing it takes up a large part of the working hours of the Oriental peoples, and customs associated with rice are found in the religious ceremonies and in the idiomatic phrases of the language.[1]

The requirements of paddy, or wet-field, rice are quite different from those of any other cereal crop. In the first place, most of the varieties of rice require a hot growing season. Since most of them also require that the fields be inundated during at least a part of the period of growth, an abundant supply of moisture must be available, either from large rivers or from a very heavy rainfall. Rice is ideally suited, then, to the monsoon type of climate, because of the very heavy rains which come during the summer months. But within the monsoon regions not all soils and surfaces are equally suited to this form of cultivation. Some places are too far from a supply of water for flooding the paddies; some soils are too porous. The best places for rice are the floodplains of the larger rivers, where there is a fertile alluvial soil and an abundant supply of water. See Figs. 23 and 24.

The relatively small amount of first-class rice land, where the most favorable conditions of climate, surface, and soil are combined, leads

[1]In Chinese, for instance, the general word for food (*fan*) is also used specifically for cooked rice.

FIG. 23. *A part of the East Indies and southeast Asia*

to the intensive utilization of these places. The land is divided into small field units, generally not more than a quarter of an acre in size. A very great amount of labor is applied to the rice crop; for after the land is plowed and smoothed, in some places with the aid of domesticated buffaloes, the remainder of the planting, cultivation, fertiliza-

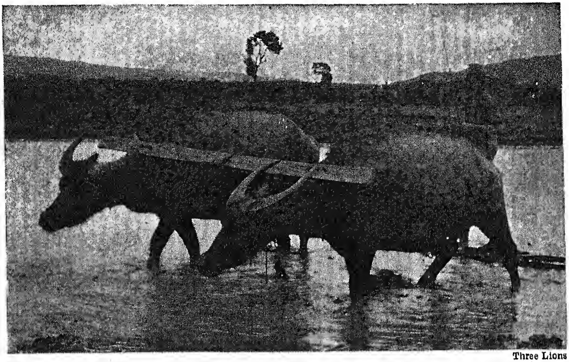


FIG. 24. *Preparing a flooded paddy in China for the planting of rice*

tion of the soil, and harvesting of the crop is done by the energy of human muscles. Dense populations are required for the production of rice by these methods and are in turn supported by its production. In parts of India and Java a population of nearly two thousand people per square mile is reported.

Perhaps under no other agricultural system is the surface of the earth so completely transformed as in the rice lands. No remnant of the original cover of vegetation is left. With certain exceptions the people live in compact villages, almost hidden by a dense growth of planted vegetation. Palms, banana plants, tall, feathery clumps of bamboo, and here and there the towering bulk of a kapok, or silk-cotton tree, or one of the several kinds of tropical fruit trees, such as the mango or the breadfruit,—all these nearly conceal the houses of the villages. Somewhat raised above the general level of the rice paddies, these villages resemble heavily forested islands, especially during the season of the year when the rice fields are brown with bare mud or concealed beneath the flood waters. Roads lead from the villages into the surrounding country, over which the workers pour out in the early morning and return at night, leaving the countryside quite uninhabited.

Bristol from Three Lions

FIG. 25. *Rice terraces in the densely populated island of Java*

Outside these nucleated settlements the rice paddies are almost uninterrupted. Here the surface of the earth itself has been remodeled. Each individual field is leveled and surrounded by a dike. In order to insure drainage, each one of the paddies must lie at a different elevation from its neighbor. Whatever may have been the original landforms, man has sculptured the surface for his own needs, neglecting no small bit of this very valuable land. Most spectacular of all is the terracing of hilly areas, where contour-like platforms outline the shape of ridges and valleys. In parts of Java rice terraces have been built on slopes of as much as 45°. See Fig. 25.

Thus a new landscape is created—a landscape which changes its color and its character with the swing of the seasons. While the fields are being plowed the scene is brown and desolate, dotted here and there with the verdant islands, on which lie the hidden villages, or with the few patches of vivid yellow-green where young rice plants have been started and are waiting to be transplanted. Then the paddies are inun-

dated, and, wading knee-deep in water, the workers set out the young plants. These quickly take root, and in the course of a week or so the pale color of standing water is replaced by the rich green of the growing crop. Myriads of water birds feed on the paddies and on the insects which breed in them, and the nights vibrate with the voices of millions of frogs. As the grain begins to ripen, the color changes again—now to a golden yellow. The water is drained away, and carefully, so as not to lose a bit of the precious crop, the rice is harvested. Again the brownish fields, thick with the stubble of rice straw, await the plowing and the repetition of the cycle. There is nothing left to suggest the tropical forest, over which man with such difficulty establishes his conquest.

Other crops also are grown in the monsoon regions. In some cases a dry-season grain such as wheat or millet, or perhaps sugar cane, is planted on the dry rice paddies. But there are great areas entirely unsuited to rice, either because of low rainfall and consequently inadequate supplies of water or because of porous soil, which allows the irrigation water to seep away too rapidly. Even in Java and India only a relatively small proportion of the country is first-class rice land and supports the dense populations previously mentioned. Of necessity, settlement spreads to the poorer, non-rice-producing areas. Here other subsistence crops form the basis of the occupance: millets of various kinds or a combination of the food crops previously described for the other regions of this group, such as maize, manioc, upland (or dry-field) rice, peanuts, and bananas and other tropical fruits.

While many of the agricultural practices in these lands were developed before the arrival of the Europeans, the capacity of this system to support dense populations has been built up during the last century under European rule. The Dutch in Java, the British in India, and to a certain extent the French in Indo-China have established a measure of security against warfare and raiding, have imposed a system of sanitation, and, in addition, have stimulated a closer attention to agriculture. The result has been in each case a rapid growth of population which, in spite of the sanitary measures, increases the problems of poverty. Java in 1815 had about 4,500,000 people, concentrated chiefly on the rich soils of the northern alluvial plain around Batavia. By 1900 the

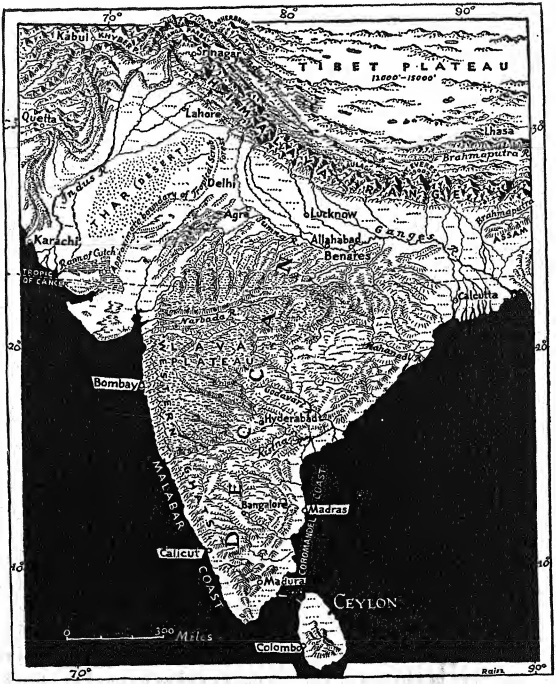


FIG. 26. *The peninsula of India*

population had increased to about 28,400,000, and in 1945 it had reached 50,000,000. Such increases, unless accompanied by numerous cultural changes, raise serious problems of food supply.

India and Pakistan. One of the world's outstanding problem areas is the peninsula now occupied by two self-governing British dominions, India and Pakistan (Fig. 27). The peninsula as a whole is over a mil-

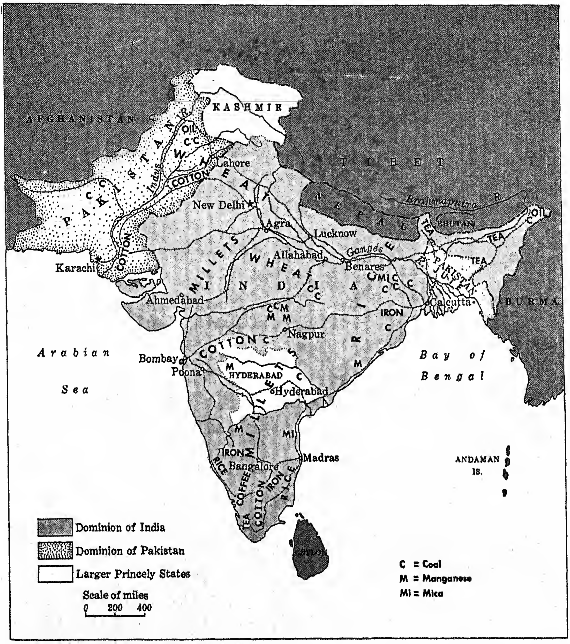


FIG. 27. *The political divisions and economic areas of India and Pakistan.* (After V. S. Gananathan)

lion and a half square miles in area, or almost as large as the continent of Europe excluding the Soviet Union, and it is occupied by more than 400,000,000 people, or about a fifth of the whole human race. Measured in terms of the area suitable for farming, the population density in India and Pakistan, considered together, is 423 per arable square mile. This is not so great as the population density of 769 per arable square mile in Java, nor the more than 500 per arable square mile in both the

Philippine Islands and Puerto Rico. But in the case of India and Pakistan this density is not a local matter; it involves a very large total number of people.

The peninsula is also an outstanding problem area because the huge population is increasing at a rapid rate. With the very high birth rate of more than 45 per 1000, any decrease of the death rate results in a sudden increase of the total population. At the present time the increase is about six million per year, or fifteen thousand per day. Even when peace and order are maintained by a strong police force, and when some attempt to provide medical service is made in the cities, the death rate remains high owing to famine and disease. Only half the persons born reach the age of twenty-two. If famines and domestic warfare do not wipe out vast numbers of people, and if the level of living is raised by industrialization or better attention to agricultural practices, the decrease in the death rate cannot fail to cause a sudden upturn in the net rate of growth. In a few decades the total number will have reached 700,000,000. To keep such a vast number of people alive, let alone to provide them with what Occidentals would consider to be a minimum standard of diet, the food supply would have to be increased three times.

A major problem in this crowded land is created by the deep-seated religious conflicts. There are approximately 250,000,000 Hindus and 92,000,000 Moslems, whose basic concepts of life are profoundly different. The Moslems are in a majority in the territories to be known as Pakistan; the Hindus are in the majority elsewhere. In addition, there are seven other major religious groups. Over two hundred different languages are spoken, and of these, twenty are spoken by at least a million people each.

In 1947, when British rule ended, the peninsula was divided into two dominions. Pakistan (Fig. 27) is separated into two parts, one in the northwest and the other in the northeast, with its capital at Karachi. The total number of people in Pakistan is 85,000,000. The remainder of the peninsula is included in the dominion of India. But India is far from being in fact a closely-knit unit, for, in addition to the 215,000,000 in the Hindu state, there are at least 100,000,000 included in semi-independent princely states. There are 562 of these, and

they range in size from Hyderabad, with 27,000,000 people, whose ruler is reputed to be the richest man in the world, to the many small holdings which are essentially independent private estates.

Of all the people in India and Pakistan, at least two thirds are directly dependent on agriculture. The kinds of crops vary considerably from place to place, however, depending on the physical quality of the land. Only a few places are suitable for the cultivation of rice, but in them a very large part of the arable land is devoted to that crop. These rice areas are places of great population density. Two of them are in Pakistan: on the Ganges-Brahmaputra Delta, east of Calcutta, and on the alluvial plain farther north, where the two great rivers join through a network of channels. The rest are in India: on the delta of the Mahanadi, on the delta of the Godavari, on the Coromandel Coast around Madras, and on the whole Malabar Coast south of Bombay. But the greater part of the country is too dry for rice. On the drier lands the chief food crops include a grain sorghum (jowar, bajra, or ragi), barley, millet, maize, and a variety of vegetables. A large proportion of the grain must be used for animal feed rather than for human food, however; for India has huge numbers of cattle (about 160,000,000 head, or more than twice the number in the United States). Because the Hindu religion does not permit the killing of animals or the eating of meat, the only use made of all these cattle is for draught animals, for which purpose they are much less efficient than horses and mules. To change this situation in favor of greater use of grain for human food would require a change in the beliefs of one of the world's oldest religions.

Some commercial crops have been raised in different parts of the peninsula. In the northwest, in Pakistan, the borders of the dry lands have been used for wheat. In some years part of the crop was exported through Karachi, but to an increasing extent it has been consumed in the cities, most of them now outside of Pakistan. Commercial crops have been raised in rotation with food or feed grains, including jute in the wet area east of Calcutta and cotton in the drier areas. The chief cotton area is in the Deccan Plateau (Fig. 28) in the part indicated on the map (Fig. 26) as a lava plateau. Here, inland from Bombay, on good quality soils derived from the weathering of the volcanic rocks, a coarse-fibered cotton is grown, the chief use of which is for low-price textiles.

Three Lions

FIG. 28. *Picking cotton for the textile mills in Bombay*

The great majority of the people who are crowded into the territories of India and Pakistan are only dimly aware of the large political and economic issues which disturb this land. Most of the inhabitants live in the hundreds of thousands of small villages scattered over all but the arid parts of the area. Each village is a self-sufficient community. The food supply comes chiefly from the immediate locality, and since the villages are usually not reached even by a road for wheeled vehicles, local crop failure cannot be relieved by shipment from outside. The map of a portion of the Mahanadi Delta illustrates this pattern of isolated settlements (Fig. 29). Each village has its own artisans, its own handicraft specialists. The people are illiterate and have little to do with the heated discussions of national policy which sound so loud in the cities or in the world outside.

In great contrast are the large commercial and industrial cities. Both Bombay and Calcutta are cities of more than a million inhabitants,

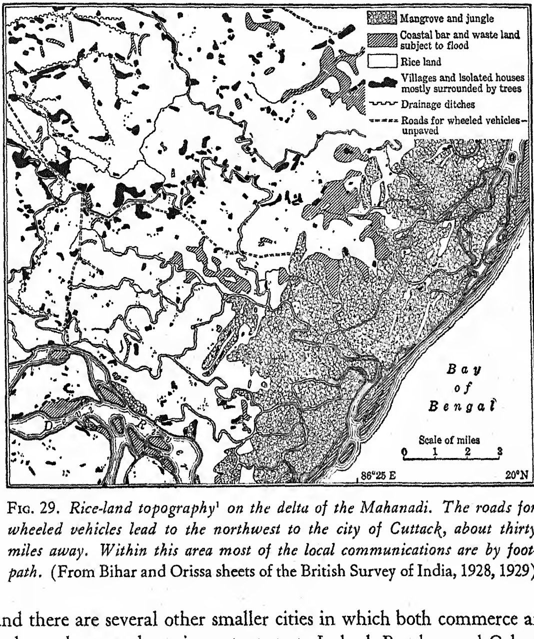


FIG. 29. *Rice-land topography*[1] *on the delta of the Mahanadi. The roads for wheeled vehicles lead to the northwest to the city of Cuttack, about thirty miles away. Within this area most of the local communications are by foot-path.* (From Bihar and Orissa sheets of the British Survey of India, 1928, 1929)

and there are several other smaller cities in which both commerce and industry have made an important start. In both Bombay and Calcutta there are big textile mills, and in a town located 155 miles west of Calcutta there is a huge steel plant which makes use of near-by sources

[1]Unfortunately the general misuse of the word "topography" has caused the loss of its original meaning. In many writings the word is now used to refer only to the landforms or the character of the surface features. In this book, however, its original meaning will be retained. It will refer to the details which comprise the landscape of a small area,—the landforms and also all the other features occurring together on the earth's surface, as on a topographic map. A topographic study refers to the study of a small area. In this sense topography, chorography, and geography form a series of increasing generalization. Chorography refers to studies of larger regions; geography, to a study of the world or of its larger parts.

of raw materials. This steel plant is the largest single unit of this sort in the world, and it is said to be the lowest-cost producer in the world. Madras is a center for the manufacture of leather goods. Manufactured goods from India have been exported for many years to pay for the essential imports of foodstuffs from Burma, Siam, and the East Indies.

The economy of Pakistan will be chiefly agricultural. In this Moslem state there will be a surplus of both rice and wheat. Pakistan also produces most of the jute of the Ganges-Brahmaputra region, although the factories for making jute textiles are all in Calcutta, which is included within India. Cotton, wool, tea, tobacco, furs, hides, and leather are produced in Pakistan beyond the capacity of that dominion to consume these things. But Pakistan has few industrial establishments. It will be dependent in considerable measure on the urban markets of India.

The part of the peninsula now included in India is the part having much the greater share of the industries and the industrial raw materials, although it is weak in terms of agricultural production. Almost all the coal and iron deposits which supply the big steel plant are in India, and nearly all the textile mills are also in this dominion. Exports include manganese, mica, leather products, shellac, oil seeds, cashew nuts, tea, coffee, and textiles.

If the problems of establishing a sound domestic government, and of developing a workable relationship between the two separate dominions can be solved, India and Pakistan, and especially India, have the man power and the resources to become important world powers. But if the food supply is not increased rapidly enough to take care of the predictable increase of population during the next few decades, India will be swept by famines of unprecedented severity, and a majority of its people will continue to exist on substandard diets close to the edge of starvation. The emergence of an industrialized state from a mixture of Oriental peoples is a painful process, and one which has great significance for the economic and political patterns of the next century.

OCCUPANCE BY OCCIDENTAL CULTURES

India has made a start toward the development of an industrialized state, but as yet it cannot be said to be a part of what we have called

the industrial society. Even where an Occidental nation has established its political control over an Oriental people, the total number of Occidentals actually in residence in the colonial country are few. In India the British have not numbered much over 125,000 except in time of war. Still fewer are the numbers of Dutch in the Netherlands Indies, or the French in Indo-China.

The lure of commercial profits led the Occidentals into the low-latitude regions of the world. This emphasis on commerce is the reason why Occidentals, more than the people of any other culture, give special attention to the development of the means of transportation—ports, navigable waterways, roads, railroads, and, most recently, airports. From the urban centers of Europe and North America Occidental influences reach out to the most remote places, and over the converging lines of transportation move the raw materials or manufactures that have been built into the way of living of the people of the industrial society. Even today the Occidental settlements in the low latitudes are mostly near the coast where they can be reached easily from an ocean port.

Effects on the Native Modes of Occupance. Although the Occidental occupance may be limited to relatively few parts of these regions, the contact of this world culture with the various native cultures has profoundly altered the native way of living. Many radical changes in the distribution of plants, animals, and even people have resulted from the development of the Occidental means of circulation. The largest Negro populations, for instance, are no longer in Africa, but in industrial North America. Among the crops maize, manioc, rubber, cacao, tobacco, and many others were known only in parts of the American continents before the Europeans carried them to other distant regions. Now the African native agriculture is organized around maize and manioc. Coffee, on the other hand, has been taken from the Orient into South America. Domestic animals, too, have been exchanged, for the American natives had neither cattle nor poultry before these were introduced by Europeans.

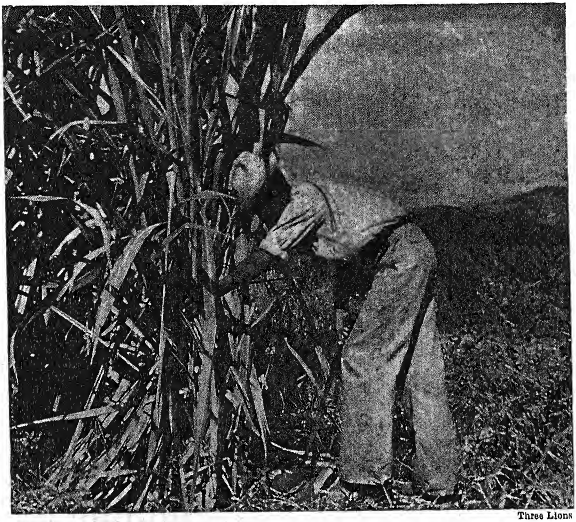
The results of the development of world circulation have not been entirely beneficent, however. Many diseases which formerly were localized in rather small areas are now widespread. The introduction

of diseases into new regions along lines of travel is not a new phenomenon, but it has never before been exhibited on such a large scale. In recent years medical science has shown the importance of controlling it and the methods of doing so.

Actual commercial contacts have also done much to change or to modify the native way of living. These involve not only the purchase from the natives of certain tropical products but also, in exchange, the sale of manufactured products from the urban industrial establishments. Weapons, agricultural implements, clothing, and liquor are traded even in remote parts of the interior for such valuable items as ivory, tropical cabinet woods, like ebony or mahogany, or other rare products collected in the forests. Where populations are dense and labor is cheap, the native peoples may be led to the production of commercial crops such as wheat, sugar cane, cotton, and many others, either by actual physical compulsion or by the establishment of economic necessity.

Occidental Plantations. There is a long list of agricultural products that cannot be grown in the middle latitudes because of climate, but which have become essential for the needs of an industrial people. Some of these are food crops; others are used in the manufacture of the many kinds of things Occidental people use. Among the food products are sugar cane, which now comes chiefly from Cuba; coffee, which comes from Brazil, Colombia, and Central America; and a long list of lesser items such as cacao, chicle, cinchona, vanilla, spices (such as pepper, cloves, ginger, and cinnamon), and many tropical fruits (such as bananas, coconuts, pineapples, avocadoes, and mangoes). Rubber is of major importance as an industrial product. Over 90 per cent of the world's natural rubber comes from plantations on the Malay Peninsula and on the island of Sumatra. Other items include Manila hemp, sisal, gums, and insecticides. Even tropical woods are coming into use as their special qualities are appreciated and utilized.

In many cases these products were first brought to the European or North American markets through the collection of the raw material from plants growing wild in the tropical forests. Later, as the demand increased, production costs were greatly lowered per unit by develop-



Three Lions

Fig. 30. *Cutting sugar cane on a plantation in Puerto Rico*

ing plantations. Much of Northeastern Brazil, the West Indies, and some other parts of Latin America were first settled by the plantation system based on Negro slave labor. The crop was sugar cane. As long as the market is good, the necessary number of workers is recruited by whatever system is in use, and the plantation is maintained under the supervision of a small number of resident whites. But such a system is essentially speculative and temporary, for not only may soils be impoverished by repeated cropping, or yields reduced by insect pests, but also other areas with lower costs may capture the market, or the market itself may collapse owing to change in fashion or taste, or to the acceptance of substitutes. The Occidental plantation is a distinct example of *raubwirtschaft,* of the temporary exploitation of a resource and probably of a people. See Fig. 30.

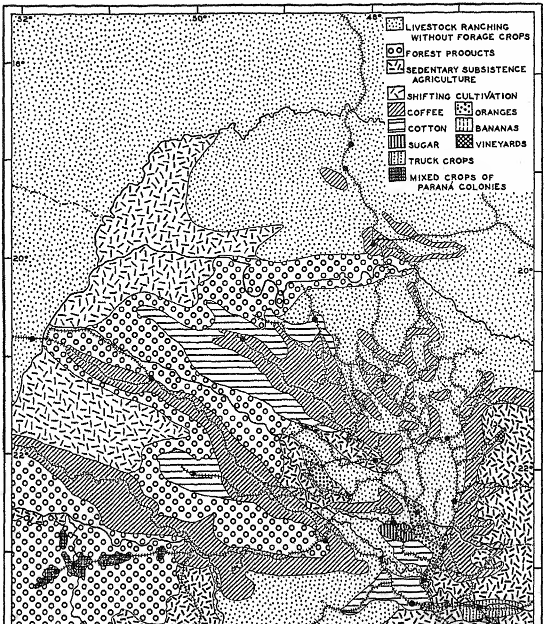


FIG. 31. *Land use in the São Paulo region, Brazil.* (From LATIN AMERICA by Preston E. James. Copyright, 1942, by The Odyssey Press, Inc. Used by permission of the publishers)

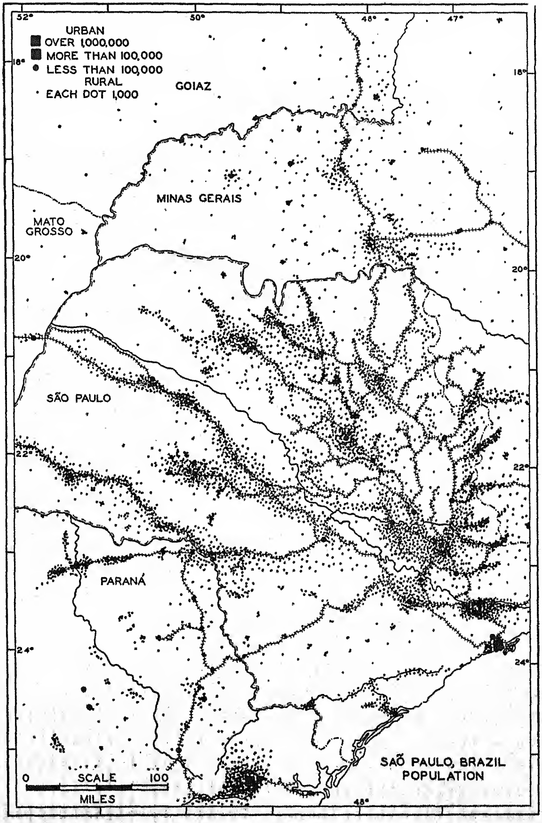


Fig. 32. *Population in São Paulo region, Brazil.* (From LATIN AMERICA by Preston E. James. Copyright, 1942, by The Odyssey Press, Inc. Used by permission of the publishers)

Occidental Settlement. The actual settlement on tropical lands by Occidental people, doing their own work, is another matter. There are three chief regions in which such settlement has taken place: the hilly uplands and plateaus of São Paulo in Brazil; the hilly upland of Northern Rhodesia and of the southern part of Belgian Congo in Africa; and the plains and hilly uplands of Queensland in northeastern Australia. In all three of these areas Occidental people have established permanent agricultural settlements in regions of Group II; and in each case settlement is based on the production of something to sell in exchange for necessary imports.

São Paulo, in Brazil (Plates 2, 11, 12), has risen to importance chiefly since the middle of the nineteenth century. To be sure São Paulo city, established in 1554, was the first Portuguese settlement on the Brazilian Highlands; and from this town expeditions went out to explore and exploit the vast interior of the continent from the headwaters of the Amazon to the mouth of the Río de la Plata. But there was not much fixed settlement in São Paulo State until the beginning of the coffee period in the middle of the last century. Since about 1880, São Paulo State has been the leading coffee-producing region of the world. Great numbers of immigrants have poured in, not only from other parts of Brazil, but from all over Europe, especially from Italy, Portugal, and Spain. There were never more than a few native Indians in the region, and almost none are left now; and few Negroes were ever brought into this part of Brazil. The work of planting, cultivating, and harvesting coffee has always been done by people of European origin. São Paulo is the economic heart of Brazil; its population is over 7,000,000. The city of São Paulo, now having a population well over a million, has become the largest center of manufacturing industry in all Latin America. In its hinterland not only coffee but also cotton, sugar cane, oranges, and a variety of other crops are produced, as well as feed for cattle on their way from the remote interior to the slaughterhouses of São Paulo and Rio de Janeiro. See Figs. 31 and 32.

European settlement in Northern Rhodesia and neighboring parts of Africa (Plates 3, 13, 14) is on a smaller scale than in Brazil. British colonists have made clearings in the open, parklike scrub forest and have established farms along the railroad which runs northward from

Livingstone on the Zambezi River toward Elizabethville in Belgian Congo, by way of Broken Hill (Fig. 33). This is the high ground which forms the watershed between the Zambezi and the Congo: it is high enough to be above the range of the tsetse fly and so is relatively healthful. Large areas suitable for a similar kind of farming are still available for new pioneer settlement along this railroad, and along the line which extends westward across Portuguese Angola to the Atlantic coast. Elizabethville has become an important commercial center and a large distributor of agricultural machinery. The chief commercial product is cattle, which are marketed in the copper-mining communities of the Katanga District of Belgian Congo. This area, unlike Brazil, has been occupied by Europeans in the presence of a considerable native population of Negroes. A major unsolved problem in the area is the relation between farm workers of different racial and,

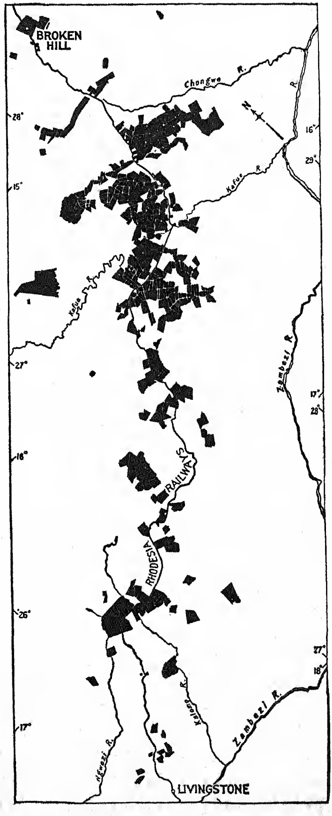


Fig. 33. *Farms in Rhodesia.* (Reproduced from *Pioneer Settlement*, published by the American Geographical Society of New York)

especially, cultural backgrounds. In contrast to the 7,000,000 people of São Paulo State in Brazil, Northern Rhodesia has a population of 1,500,000, of which about 14,000 are British farmers.

The spread of white settlement northward in Australia has penetrated lands which were essentially empty of human inhabitants (Plates 6, 19, 20). Pioneers have pushed along the coast north of Brisbane, chiefly within the narrow band of tropical semideciduous forest. Here sugar cane and cotton are produced entirely with white labor. In northern Queensland and in southern Florida are two areas where workers of European descent have been successful in carrying on farming at sea level in the low latitudes. The Queensland area has been made the subject of much study and may ultimately offer an answer to the problem of white settlement in the tropics.[1]

The spread of settlement along the whole northern coast of Australia will apparently be more difficult than the movement north of Brisbane. To the west the monsoon climate is one of mild, dry winters and hot, rainy summers. The vegetation is mostly savanna with patches of scrub forest along the coast. Today this coastal land is very thinly settled. The problem of holding it against the pressure of Oriental people in the crowded regions of southeastern Asia is one which causes the Australians much concern, for sooner or later the land must be occupied by Australians if the pressure from the north is to be withstood.

Conclusion

The forest still dominates the landscape in most of the areas of this group. The high temperatures and the absence of a winter, the rank vegetation which springs up with such rapidity in every open space, the teeming exuberance of all forms of life, have conspired to create in the minds of middle-latitude visitors the impression of easy living in the midst of an abundance of resources. But this impression is actually far from the truth. The prevailing poverty of the soils is not reflected in the vegetation cover; for the heavy leaching and eluviation and the lack of humus are brought about by those same conditions of the

[1] A. Grenfell Price, *White Settlers in the Tropics*, American Geographical Society, Special Publication, no. 23, New York, 1939.

climate which produce the forest, namely, high temperature and humidity. Easy living is possible if wants are few. But the real conquest of the forest for the permanent establishment of human settlement has been accomplished only where great numbers of people have been willing to live lives of unremitting and persistent toil. The way of the pioneer is indeed hard; for those things which can be accomplished by great numbers of patient workers do not yield easily to the isolated frontiersman.

People with different cultural heritages face the problems of living in these regions in quite different ways. For the primitive forest dwellers, with simple culture and few wants or ambitions, life is not at all difficult. These people do not attempt the conquest of the forest, but rather are content to accept such living as the untamed selva provides. Until white men came to develop new wants and to spread new diseases, distress or poverty was probably little known. This kind of human occupance, however, develops no fixed patterns of distribution and leaves few traces of its existence on the land.

People with a somewhat more elaborate cultural heritage, on the other hand, have been unwilling to accept the primitive existence afforded by the forest and have sought to establish themselves more permanently on the land. During the course of history a number of such groups of people have actually been able to gain a temporary dominance over the forest. Clearings have been made over a considerable area, and by some variant of the native garden type of occupance a large agricultural productivity has been developed. But this type of conquest is no more permanent than the primitive one. The soils have not withstood continuous agricultural utilization, but have gradually deteriorated until the decreasing food supply could no longer support the increasing population. The ruins of ancient civilizations, such as those of Central America and of Siam, are now overgrown with a dense jungle cover, all but obliterated by the victorious forest.

The massed human hordes of the rice cultures have succeeded in making their conquest permanent. By completely transforming the original scene they have left no trace of the forest, and by persistent labor they leave no opportunity for its return. The crop around which they have built their way of living yields enough sustenance to support

as many as five hundred people per square mile. But only relatively few square miles possess just those qualifications of climate, surface, and soil which permit rice cultivation. On these suitable areas, therefore, the population is concentrated densely, and the use of the land is intensive. The patterns of settlement thus established are fixed and crystallized. Although hitherto this type of occupance has been developed almost exclusively in the Orient, there are many parts of the African and American tropics which are suitable. The Amazon Basin is physically capable of supporting an enormous number of people—another major nation, but one which will occupy the land in accordance with the Oriental mode.

The Euro-American mode of occupance is quite different. Two chief considerations govern the distribution of settlements. In the first place, the emphasis on commercial relationships with the middle latitudes enforces a close connection of all settlements with the coastal ports. In the second place, white people seek to avoid those hot, humid lowlands so much desired by the rice-growers and concentrate instead on the cooler uplands. The contrast between the patterns of population distribution in Brazil and in southeastern Asia is striking. Yet these two considerations which govern the localization of Occidental settlements are not harmonious: elevation provides relief from the lowland heat and humidity, but at the same time it renders access from the coast much more difficult and brings foremost the problem of transportation.

The Amazon Basin, suitable as it may be for Oriental occupance, is nevertheless politically under the control of a Western nation. Many other parts of the tropical forest lands, notably northeastern Australia and parts of Africa, are in the same situation but on a smaller scale. One of the great problems of the future is the question of whether or not these great empty regions can be occupied by white people and whether white people can establish their hold on these areas in the face of the very effective occupance by people of Oriental culture. The enormous increase of population in southeastern Asia must inevitably lead to expansion, and, but for the political and economic control of the Europeans and Americans, vast new lands await the Oriental colonist. The outcome is not easy to predict.

GROUP III

THE MEDITERRANEAN SCRUB FOREST LANDS

At a time when little of the world was known, and when Western culture was beginning its development in the Mediterranean[1] countries, Aristotle set forth his famous classification of climates. With the hot, dry Sahara to the south, and with the cool, rainy forest lands of Europe to the north, it is little wonder that the Mediterranean world, with its mild temperatures, its abundant sunshine, and its scanty but sufficient supply of rain, should seem to him the most "temperate" of all lands. His classification of the world he knew included three zones: a torrid zone, too hot to be inhabited by civilized men; a frigid zone, too cold and stormy for any but barbarians; and a temperate zone, the home of the Greek culture, the only habitable part of the world. It is a remarkable evidence of the keenness of Greek thought that on *theoretical grounds alone* the existence of a south temperate zone and a south frigid zone was postulated. This classification is perfectly understandable in view of the knowledge the Greeks possessed, although the application of these zones to the world as a whole has been very misleading. It is to these "temperate" lands of Aristotle and their counterparts in other continents—for some cultures, perhaps, the pleasantest of the world's habitats—that we now turn our attention.

In many ways the classification into zones developed by Aristotle points out the salient peculiarity of the regions of this group. They are essentially transitional; yet in the zone of transition are developed a number of striking characteristics which make them unique among the world's habitats. Transitional in climate, most of the regions of this group lie closely hemmed in between high mountains and the sea. This transitional character is further emphasized by the position of the

[1]The borders of the Mediterranean Sea make up the most extensive area of this group. The use of the name "mediterranean" to refer to all the analogous regions throughout the world is in accordance with common practice in other writings on regional geography. In this book Mediterranean will be written with a capital M when it refers to the lands about the Mediterranean Sea, and with a small m when it refers to the group as a whole.

Mediterranean Basin, on the margins of which are the coasts of three continents—Europe, Asia, and Africa.[1]

The mixture of ideas coming from such widely separated parts of the earth gave to the new cultures developing in the Mediterranean Basin that vitality which arises only as a result of the compounding of diverse elements. During the many centuries of the classical period the Mediterranean peoples were drawing greatly contrasted culture traits from the ends of the known world, and from the clash of these varied ideas and modes of living the fundamentals of what is now broadly called "Western culture" were being worked out and established. History has given abundant proof of the fact that cultural growth takes place not in sheltered spots, but in places where the currents of travel converge,—where all kinds of people come together. Sheltered and isolated places are more commonly regions of survival, where ancient and traditional ways of living are preserved. The evolution of a new culture out of the accumulation and digestion of diverse elements at a focal point in the world lines of circulation is perhaps best illustrated by this "cradle of Western civilization."

The major lines of travel no longer converge on the Mediterranean lands of the Old World. The present larger foci lie elsewhere. Many of the analogous regions in other continents, especially those of the Southern Hemisphere, are notably handicapped by their remote position in the economic world. But all the regions of this group share with the Mediterranean Basin the more permanent qualities of transition: those related to the climate and to the surface features.

For various reasons, then, the significance of the regions of Group III in terms of human affairs, especially in the building of the Occidental culture, is much greater than the total area of these lands would suggest. Of all the world's land masses, only about 1 per cent has this peculiar type of climate and this unique type of vegetation. Yet on this small area are found today about 4 per cent of the world's population.

[1]Our concept of the separateness of Europe, Asia, and Africa is inherited from classical antiquity, when the three sides of the Mediterranean stood out as sharply differentiated, not only physically but also in the very different cultures of the inhabitants. The modern notion of Eurasia—of Europe as a peninsula of Asia—was developed only after the world map had been much more completely filled out.

The Land

CLIMATE AND VEGETATION

The unique character of the landscapes of this group rests fundamentally on the peculiarities of the climate. In the various parts of the world it is not unusual to find rainfall more or less evenly distributed throughout the year or to find places where there is a summer maximum of rainfall with a winter dry season. The outstanding peculiarity of the mediterranean climate is its winter rains and summer droughts. Lying generally on the west coasts of the continents poleward of the deserts, the regions of this group have a climate that is transitional between the semiarid climates and the cool, rainy climates of the higher middle latitudes, poleward of 40° (Plate 8). As one proceeds away from the deserts the amount of winter rain increases and the length of the summer dry period decreases. The typical mediterranean climate is divided into a hot summer with brilliant sunshine and clear blue skies, and a mild winter with irregular periods of rain.

The mediterranean summers resemble those of the deserts. Near the arid boundary the summer drought may extend over a period of five or six months, as in Palestine; but on the poleward margins of the mediterranean lands the drought may be reduced to only one month. Typically the driest month receives no rain at all, but near the poleward margin a little rain may fall even in summer. Day after day the sky remains cloudless. The wind, which becomes quite strong near the water, picks up clouds of dust from the dry earth. Most parts of the mediterranean lands become very hot during these summer months; but near the open oceans, where cool water bathes the coast, the summers are cool and, along the California coast, foggy (Fig. 34).

The mild winters, on the other hand, are quite different from the monotonously clear summers. The winter temperatures generally average between 35° and 50° for the coldest month. If destructive frosts and snows occur now and then, they are destructive more because of their rarity than because of their severity. During this season the weather is variable; there are spells of warm, muggy, rainy weather with cloudy skies, followed by cool and brilliantly clear periods.

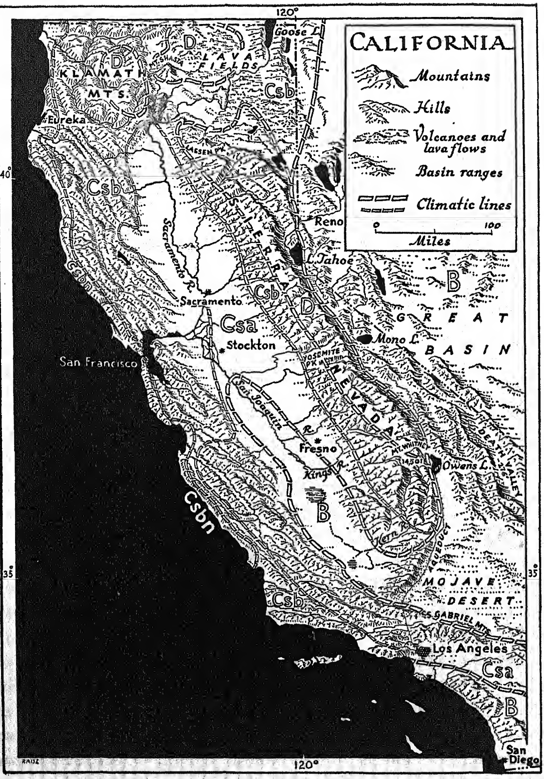


FIG. 34. *Surface and climates of California.* (Climates after R. J. Russell)[1]

Cold Air Masses. These varying spells of weather result from the passage of typical middle-latitude storms. We have already noted the characteristic monotony of low-latitude weather. The middle latitudes, in contrast, are variable in weather; so much so that the traditional term "the temperate zone" is highly misleading and has been dropped by many geographers. If we recall the discussion of the major wind systems of the low latitudes, we remember that over the eastern parts of the ocean basins about 30° N. and S. are found the centers of great whirls of air of planetary proportions. The equatorward half of each whirl is marked by air moving from the east, the northeast, or the southeast. The prevailing wind direction in the poleward part of each whirl is from the west, the northwest, or the southwest. The oceanic whirl sweeps over the margin of the neighboring continent, and, unless mountains interfere, penetrates inland as far as is permitted by the deflective force of the earth's rotation. Because of the location of the regions of Group III between 30° and 40° both north and south of the equator on the western sides of the continents, the prevailing wind directions are northwest and north in the Northern Hemisphere, and southwest and south in the Southern Hemisphere (Plate 26). The strong north winds which sweep across Greece, the Aegean Sea, and the eastern Mediterranean were so well known to the ancients that they were given the name *Etesian Winds.*

Another element of the world's climates, however, interrupts the oceanic whirls from time to time. From the snow or ice surfaces of the polar regions come surges of cold air. These cold air masses, being heavy, lie close to the ground, and when they encounter the relatively warm, light air of the oceanic whirls they push under it and force it to rise. In this way, as the cold air masses move forward, the warm,

[1]On the map, Fig. 34, the climates are shown by lines and letter symbols. These are the symbols of the Köppen system, which are explained in Appendix B. Qualitative descriptions for each of the types of climate shown on this map are:

B = Arid or semiarid climates
Csa = Mediterranean climate with mild, rainy winters and hot, dry summers
Csb = Mediterranean climate with mild, rainy winters and cool, dry summers
Csbn = Mediterranean marine climate with mild, rainy winters and cool, dry summers with frequent fogs
D = Mountain climates with cold, snowy winters

moist oceanic air is forced to rise and cool, thus forming clouds and bringing rain. The wedge of cold, dense air along which the warm air rises is called a *front*. The cold air masses are known as *polar outbursts*. From both arctic and antarctic regions they move out toward the nearest warm places. Especially strong outbursts have been known to travel all the way to the equator, but usually they are limited to the middle latitudes, and, as they move equatorward, they are picked up in the stream of westerly winds and moved off eastward.

In winter the polar outbursts are especially strong. At this time of the year, therefore, they push farthest toward the equator. On the continental west coasts in winter cold air masses are occasionally strong enough to push beyond latitude 40°, but in summer such air masses rarely cross latitude 40°. Between 30° and 40° on the continental west coasts there is a transitional type of climate which receives rain only in winter, but which shares the dry desert climate with the regions of Group I during the summer.

The winds associated with a passing cold air mass have all been given local names in the Mediterranean countries of Europe. When the cold air pours southward through the Rhône Valley, it is known as the *mistral*. When it pours over the mountainous border between the Danube Basin and the Adriatic Sea (Plate 15), it is known as the *bora*. Because it drops rapidly over the coast of Yugoslavia, it is warmed adiabatically[1]—the bora is a very dry wind that desiccates the crops and picks up clouds of dust.

When a cold air mass pushes into the stream of the oceanic whirl it sets up eddies along its front. In the Northern Hemisphere these secondary whirls rotate in a counterclockwise direction, and in the Southern Hemisphere they rotate clockwise. Meteorologists describe such a whirling storm on the front of a cold air mass as a *cyclone*.[2]

During the passage of one of these secondary whirls in the Mediterranean Basin, the winds come from various directions. Normally, as the cold air mass moves southward, the cyclone advances toward the

[1]For a discussion of such meteorological processes see Appendix B.

[2]Note that there is a distinction between the popular use of the word "cyclone" to refer to a very violent storm, such as a hurricane or tornado, and the technical use, which includes under the term "cyclone" all whirling storms. When the word "cyclone" is used without modification, it refers to these general storms characteristic of the middle latitudes.

east. At any one place, the coming of a cold air mass is first heralded by an interruption of the prevailing north or northwest winds. The winds are at first variable, and then come strongly from the south and southeast. The warm, dust-laden air from the Sahara is called the *sirocco*. Crossing the warm Mediterranean Sea, this air picks up large quantities of moisture. North of the Mediterranean, as the cold front approaches, cloudiness increases and usually there is rain. Where the air contains much dust the first showers are apt to contain large amounts of mud. Then, with a sudden shift of the wind to the north or northwest, the skies become clear, and bracing, cool air replaces the depressing air of the cyclone. Such a succession of weather types is experienced several times during the winter. There are similar weather types in all the other mediterranean regions of the world.

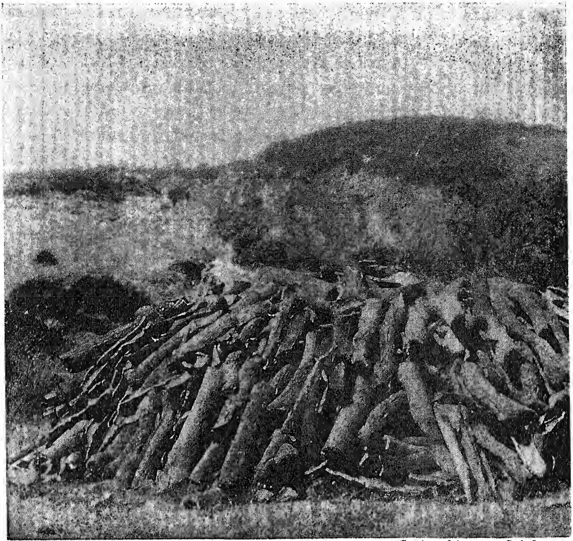
Rainfall occurs as the cold front sweeps on toward lower latitudes. It is widespread throughout these regions, but in any case is heavier in mountains and hilly lands than on level lands. Wherever air is forced to rise, it is cooled; and eventually, if it rises far enough, the moisture in the air is condensed to form cloud and rain. In the dry lands, we may recall, rains come frequently to the mountains. In the mediterranean lands the higher mountains are almost always cloud-capped. Because the prevailing winds are from the west, the western slopes of mountains and hilly uplands receive more rain than the eastern slopes. One result is an abundant supply of water for irrigation in all the mediterranean regions of the world where there are bordering mountains.

The Mediterranean Forest and Brush. These climatic conditions support a scrub forest of unique character. The mediterranean vegetation may be described, at somewhat greater length, as a broadleaf evergreen, sclerophyll, scrub forest. Although in the different continents different species and even genera compose the forest, the appearance of the vegetation, resulting from its adaptation to the peculiarities of the climate, is strikingly similar in all the regions of Group III. The broadleaf evergreen forests of southern Europe, for example, are composed mostly of various kinds of oaks (of the family *Fagaceae* and chiefly of the genus *Quercus*), while the similar forests of Australia belong to the *Myrtle* family, of the genus *Eucalyptus* (Fig. 35).

FIG. 35. *A eucalyptus forest in Australia*

In all these forests, however, certain common characteristics appear. The winters are not cold enough, or the summer droughts long enough, to enforce a period of rest, and as a result there is no season when the leaves drop from the trees and growth ceases. The sprouting of new leaves and the accumulation of reserves take place in the fall at the beginning of the rainy season, and the flowering and reproduction take place in the spring at the end of the rainy season. In this way the mediterranean vegetation differs from the selva, which is also evergreen but which has no seasonal rhythm. Furthermore, the seasonal rhythm of the mediterranean forest is of a quite different nature from that of the tropical semideciduous forests, or of the deciduous forests of the middle latitudes.

In numerous ways this mediterranean forest adapts itself to the summer droughts. The individual trees are widely spaced so that each may draw supplies of water from a large area of ground. Between the larger trees there is a heavy growth of underbrush. On all the plants



Courtesy of Armstrong Cork Company

FIG. 36. *Bark of the cork oak drying for shipment in a forest in Spain*

deep taproots and a wide development of the surface root are characteristic. The woody and fibrous parts of the plants are emphasized, and the foliage is relatively light. The evaporation from the plants is diminished by a thick bark (notably in the case of the cork oak, *Quercus suber*) and by the nature of the leaves, which are small, thick, and stiff, with hard, leathery, and shiny surfaces.[1] Very commonly spines and thorns are developed, as in other typically xerophytic vegetation types (Fig. 36).

In addition to the scrub forest, many parts of the mediterranean lands are now covered by a low growth of bushes and shrubs, known in Europe as *maquis* and in the western United States as *chaparral*. In

[1]This characteristic leaf form is described by the botanists as *sclerophyll*.

some regions this is known to be a second growth which followed the removal of the original forest; but in other regions it is supposed that the maquis itself is a native type growing in places which, for one reason or another, are unsuited to the forest. It is composed mostly of the plants which make up the undergrowth of the scrub forest: of dwarf or scrub oak, chestnut, and various kinds of myrtle and laurel. A cover of this sort is almost worthless, for only goats can graze on the bark and leaves, and the growth is too thick to permit the existence of grasses.

An outstanding exception is California. Many of the hills and lower mountain slopes of this part of Group III are covered with grasses. During the dry summers this vegetation cover turns a yellowish brown, against which the dark green of the oaks stands out in most striking contrast. These grasses, however, are all of European origin. The original vegetation cover was probably the chaparral or the evergreen forest; but the introduction of foreign grasses into Mexico by the Spaniards was followed by a very rapid spread of these plants—so rapid, in fact, that they were already common in California at the time the first missions were established (Fig. 37).

Bordering Vegetation Types. Most parts of this group are closely hemmed in by high mountains and deserts. Closely associated with the mediterranean vegetation, therefore, are types which really belong in the mountain lands or the dry lands. While the broadleaf sclerophyll forest invades the lower slopes of many of the bordering mountains, the higher, or wetter, slopes in many places support dense stands of coniferous forest. The pine and cedar forests of the mountains bordering the Mediterranean Sea were widespread in ancient times (for example, the cedars of Lebanon). There are similar pine forests in the other mediterranean regions; and in the fog belt of the California coast, mostly north of San Francisco, are the stately groves of redwoods.

Grass is found in few parts of these regions outside the United States. Grassy areas of small extent exist in the cloud zone high in the mountains or in the marshy lagoons along the coast. In dry pockets, also, steppe grasses are the characteristic type of vegetation. But although such areas are found in nearly all the mediterranean regions, the grasses are much more widespread in California than elsewhere.

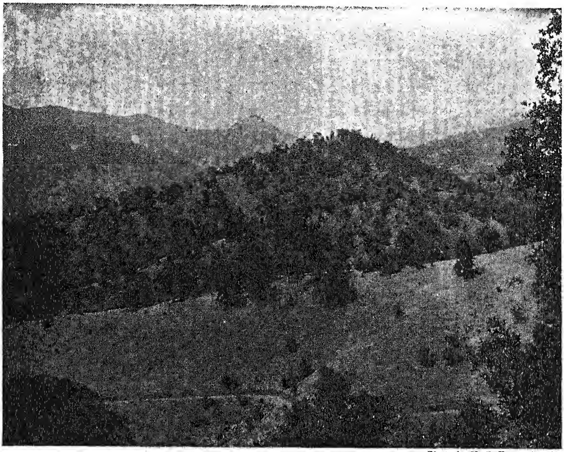


Photo by U. S. Forest Service

FIG. 37. *Mountain slopes in California covered with evergreen oak and grasses*

Distribution of the Regions of Group III. The mediterranean forest and the peculiar climate it reflects are found characteristically on the west coasts of the continents between about 30° and 40° N. and S. There are five such locations in the world. The largest area borders the Mediterranean Sea, extending from Portugal and North Africa in the west, eastward to Palestine, and northward to include parts of the shore of the Black Sea such as the southern side of the Crimean Peninsula, which is known as the "Soviet Riviera" (Plates 10–20). In North America the area included in this group lies between Los Angeles and the southern part of Oregon. In Middle Chile it lies between Coquimbo on the southern margin of the dry lands, and Concepción on the northern margin of the rainy forested region of the south. There is a small area of this group in South Africa around Cape Town. The fifth locality is in Australia, where it is divided into a western area around Perth and an eastern area in the neighborhood of Adelaide.

SURFACE FEATURES AND DRAINAGE

Few are the landscapes of this group which do not include either the mountains or the sea as a background. The mediterranean vegetation covers the immediate coast and the lower foothills of mountains which, in many places, rise directly from the water. Among the mountains there are numerous small and isolated valley lowlands and delta plains where the rivers empty into the sea. The surface features of Greece illustrate this complex pattern of lowlands closely hemmed in by mountains (Fig. 38). From the accompanying map we can understand the background of the growth of the many independent city-states of ancient Hellas, each based chiefly on its own physically distinct area of lowland. Most of the lands around the Mediterranean Basin are of this sort: small, isolated valleys or delta plains bordered by hills and backed by ranges of high mountains. No really extensive areas of lowland exist.

Compared with the complex arrangement of plains and mountains around the Mediterranean Sea, the surface features of the other parts of Group III seem relatively simple. In both North and South America (Figs. 34 and 39) ranges of high mountains lie parallel to the coast, and the lowlands and hilly belts are longitudinal. In California, west of the Sierra Nevada, lies the broad Central Valley, drained mostly by the San Joaquin and Sacramento rivers. In the southern part of this depression lies the basin of Tulare Lake—a dry-land bolson with its playa. Between the central lowland and the Pacific there are several ranges of hills separated by narrow longitudinal valleys. Because of the trend of hills and lowlands in this region, which differs slightly from the trend of the coast, some of the longitudinal valleys open out to the sea,—for example, the Salinas Valley. The entrance of the sea through the Golden Gate into San Francisco and San Pablo bays partly drowns the lower parts of a number of these valleys. Toward the north the central lowland of California is terminated by the mountains of southern Oregon, which extend westward to join the Klamath Mountains along the coast.

In Chile (Fig. 39) there is a central valley, crossed at right angles by the rivers coming from the east, and separated by projecting ridges

FIG. 38. *Greece*

of the Andes into more or less distinct basins. Between this longitudinal valley and the ocean is a coastal hilly belt. North of Santiago the longitudinal valley is pinched out by the spurs of the Andes, which reach westward to the coast. The southern part of the central valley, south of the Río Bío-Bío, is heavily forested and is included in Group IV.

Only in South Africa and Australia are the bordering ranges of high mountains lacking (Figs. 12 and 50). Even here there are prominent escarpments, as in South Africa, or ranges of hills, as the Flinders Range, north of Adelaide. Only in southwestern Australia is an area of this group developed on a surface which lacks even hills.

Relationships with the Mountains. The intimate connections between these plains and the mountains close by are many. In the first place, the relatively heavy rains in the highlands feed numerous torrential streams. Even where the climate is deficient in moisture the mountain piedmonts are supplied with such an abundance of water from the streams that a continuous band of irrigated land can be supported. Then, again, these vigorous, youthful streams in the mountains accomplish a great deal of erosion. The gravels and sands which they bring down with them to the lowlands are piled up in huge alluvial fans along the piedmonts. Where the streams descend directly into the sea extensive delta plains are formed. So great is the amount of load brought down by the rivers that the delta plains grow with remarkable rapidity. In the Mediterranean Basin delta growth is aided by a tideless sea; many towns which are known historically to have been situated on the ocean are now located many miles inland. Owing to the concentration of the rain during the winter season, the regimen of these streams shows a maximum in that season, whereas the summer is a period of low water. However, where the streams rise high enough in the mountains to reach the snow fields, the maximum flow comes during the melting period in the spring and early summer, and considerable water is available in the rivers well on into the dry season.

The removal of the forests from the mountains has in many areas seriously changed this regimen. Forests have the effect of retarding the runoff during a rain and also of delaying the melting of winter snows. The vegetation cover therefore makes the flow of the streams

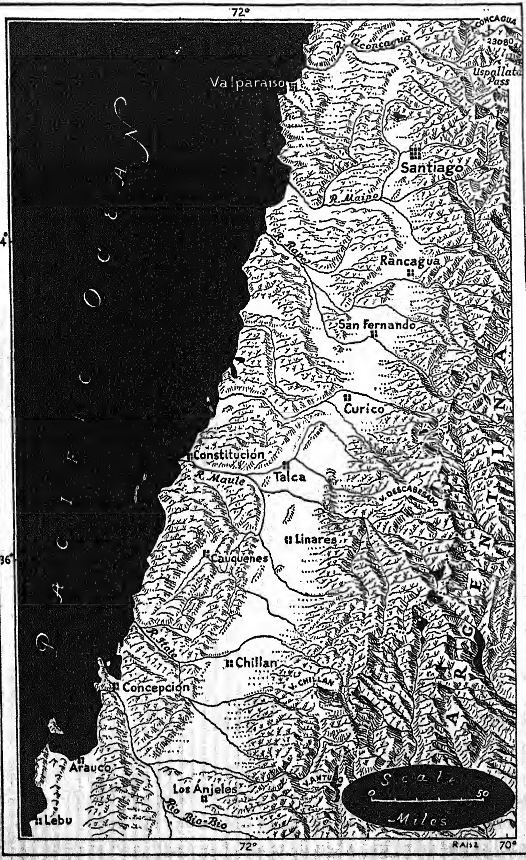


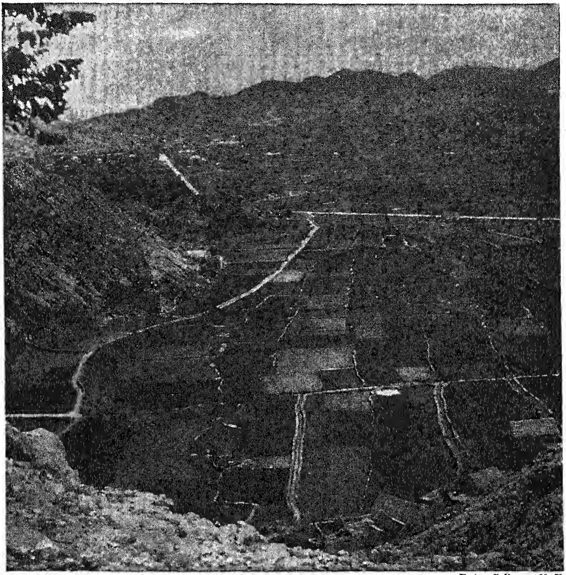
Fig. 39. *Northern Middle Chile*

more uniform. The removal of the forests causes severe floods during the winter and spring, and during the summer these floods are followed by droughts, when the streams may become entirely dry. The original forest cover of most of the regions bordering the Mediterranean Sea has been very largely cut off, and this has seriously affected the habitability of the lowlands.

The Karst Lands. The presence of a large amount of soluble limestone in the regions bordering the Mediterranean Sea results in the widespread development of *karst* landforms. The opening of caverns underground and the resulting disappearance of the streams from the surface create a landscape of more arid appearance than the climatic conditions alone would warrant (Fig. 40). Many of the plateaus and hilly uplands are of little value except for poor grazing for sheep and goats. The most habitable spots in such areas are to be found in the bottoms of the larger sinks, or *uvalas*, or on the narrow delta plains along the coast. The prevalence of karst landscapes in the countries of the Mediterranean Basin distinguishes these areas from the analogous regions elsewhere.

Relationships with the Sea; Types of Shores. Since all the various regions of this group are on the continental margins, the character of their shores is a matter of great significance. The northeastern part of the Mediterranean Sea, with its many harbors and its clusters of islands, provided an ideal setting for the early development of the art of navigation. The difficulties of overland connection were more than compensated by the ease of sea travel. Without the contacts by water the spread of the various cultural influences from one shore to another around the Mediterranean Basin would have been very difficult.

Parts of the borders of the Mediterranean Sea are shorelines of submergence; that is, they are embayed by a lowering of the land with reference to the water (Fig. 237). However, the results of submergence are somewhat different when there are mountain chains with axes parallel to the shore and when there are chains with axes at right angles to the shore. In the first case a number of elongated offshore islands are formed, but there are few projecting promontories and few deep



Ewing Galloway, N. Y.

FIG. 40. *A Karst landscape in Yugoslavia*

embayments. An example of this type is the eastern side of the Adriatic Sea—the Dalmatian coast (Figs. 38 and 45). On the other hand, if the mountain axes are at right angles to the shore, long fingerlike ridges project seaward, with strings of partly submerged summits beyond them. Between these ridges there are deep embayments leading well inland and providing fine harbors. The Aegean Sea is bordered by coasts of this sort, of which southern Greece provides an outstanding example.

Most of the shores of the Mediterranean, however, are not indented. In some cases, as on the Rif coast of northwestern Africa or the Riviera

of France and Italy, the mountains rise precipitously from the water's edge; but in other cases the shore is low, as in much of western Italy. Most of these various shorelines are shorelines of emergence (Fig. 238). In any case they have been modified by the action of waves and currents.

The borders of the mediterranean regions of other continents are mostly emergent. The western coast of the United States from Puget Sound southward has no large harbors except for the one magnificent example produced by local submergence at San Francisco. The mediterranean coast of Chile is entirely lacking in harbors; even at Valparaiso, the chief port, the shipping must be provided with artificial protection behind a breakwater. Though there are several broad embayments near Adelaide, in Australia, the shores of these embayments are straight and offer only a few harbors. Also because of the large tidal range on the open oceans, these analogous mediterranean regions do not have so many delta plains along their coasts as do the lands bordering the Mediterranean Sea.

The Occupance

The regions which border the Mediterranean Sea have been occupied by relatively advanced and complex cultures for long periods of time. The Mediterranean has been called the "cradle of Western culture," and many of the traditional Western beliefs and practices can only be understood when placed against the background we have just described. But Western culture has been evolved from the fusion of numerous earlier types, with important contributions derived from many very different kinds of people.

Occupance of the Mediterranean Basin. The settlements of the Mediterranean Basin have gone through what appears to be a well-defined succession. The earliest ones were placed back from the coast, usually on defensible highlands. At a later stage, as population increased and as there was increased protection from the raids of pirates, people descended from the hills to form towns near the agricultural lands on the well-watered plains. At this stage some of the town people ceased to interest themselves in primary production, that is, in the pro-

duction of foods or other materials from agriculture or fishing or from the direct use of natural resources. Instead they made a living by trading, manufacturing, or transporting goods, or in politics or education. These so-called urban activities were carried on by town people who became quite distinct from the people who tilled the soil or watched the herds of domestic animals. The towns grew in proportion to the size and productivity of the territory for which they performed these urban activities. A few of the larger ones, such as Athens and Rome, extended their connections by both economic and military conquest beyond the immediate districts which gave them a start, exchanging commodities with distant parts of the Mediterranean Basin and even with such distant places as Britain and the Orient. Athens came to depend for its wheat supply on shipments from the plains north of the Black Sea. Life in these communities became far more varied and more secure than in the earlier self-sufficient city-states. Thus were formed the seeds of the urban tradition which in modern times has led to the growth of those vast commercial and industrial metropolises which now perform the urban functions for the whole Occidental world.

A visible result of the basic difference between the commercial-minded Occidental society and the self-sufficient Oriental society can be seen by comparing Figs. 29 and 41. In the delta plain of the Mahanadi, in India, the numerous villages are not accessible by road. Only footpaths connect each village with its bordering rice fields. But, in contrast, the plain of Florence, in Italy, is crossed by numerous roads, giving each separate farm access to a market town, which, in turn, is connected by rail and boat line with all the commercial cities of the world.

In the modern period the lands bordering the Mediterranean Basin are, on the whole, densely populated. The distribution of people, however, is very spotty. In Italy, for example, the population is concentrated on the coastal and river plains which are not too marshy, whereas the hilly and mountainous areas have fewer inhabitants (Plates 4 and 15). The plain on which Naples is located has the densest agricultural population in Europe, estimated at about 2000 people per square mile. While this is extreme, many of the delta plains have populations of

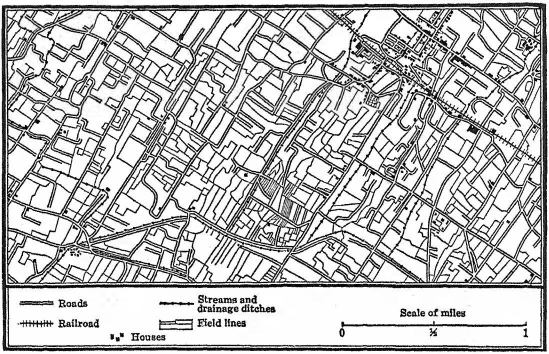


Fig. 41. *Topographic detail of a densely populated agricultural lowland—a portion of the plain of Florence.* (Adapted from O. Marinelli, *Atlante dei* Tipi Geografici, Firenze, 1922)

200 or 300 people per square mile, and several in Italy have more than 500. Compared with the population densities of the rice lands of the Orient, these densities are not excessive, but for agricultural lands based on other crops than rice such population densities are close to the limits of subsistence.

Agriculture. The agriculture which forms the basis of settlement has consisted since ancient times of a unique combination of crops. The tree crops include figs, olives, peaches, plums, almonds, and citrus fruits such as lemons and oranges. Few are the regions of this group which do not produce the vine. The grain crops include barley and wheat; the latter is thought to have originated in the eastern Mediterranean. A great variety of vegetables and flowers are raised where access to a market can be had. Though many of these crops are produced outside the regions of Group III, the combination is peculiar to this group alone.

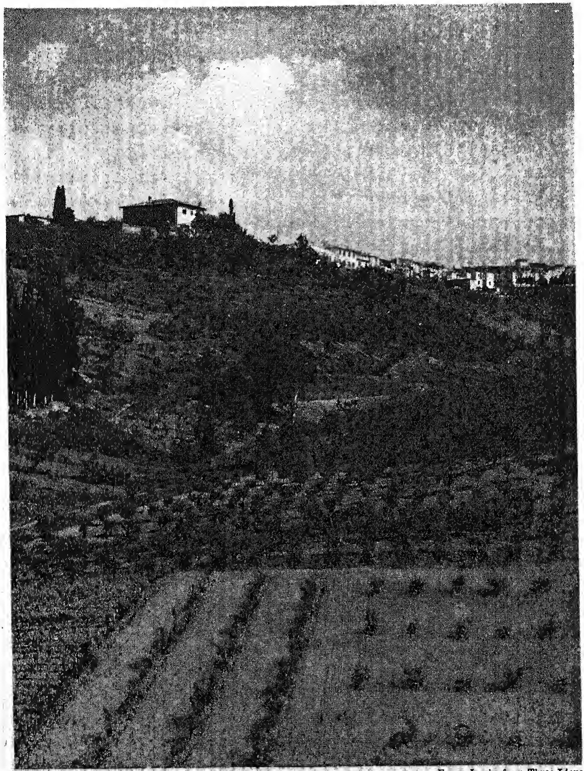
Under the prevailing climatic conditions of summer drought, irrigation is a necessity in places where more than a scanty population is to

exist. The abundant water supply in the mountain streams makes irrigation much more dependable than in the dry lands. Irrigation systems in the Mediterranean Basin date back to the earliest times. Many of the legendary heroes of Greece and Rome, such as Cadmus and Hercules, were hydraulic engineers whose fame rested on their control of rivers. The drainage of lakes, the damming of streams, and the construction of canals to carry the water great distances were all accomplished by the ancients. Roman aqueducts carrying water hundreds of miles from the mountain sources to the agricultural plains or the urban centers have been continuously in use now for many centuries.

The kind of crops irrigated depends on the rainfall; for near the desert margins the vines, olives, and figs must be watered, whereas in the areas with more abundant rains these crops are placed on the hill slopes, and only the plums, almonds, citrus fruits, and summer-planted crops are irrigated. Wheat commonly occupies the lowlands during the winter season, and is followed during the summer by irrigated alfalfa or by vegetables and flowers. Vegetables and flowers seem to have been important in early times; the former made up an important part of the diet of the ancient Greeks and Romans, and flowers were used at all the games and ceremonies and, with olive oil, in the manufacture of perfumes. The year-round productivity of the land thus made possible by irrigation greatly increased the number of people who could be supported in an area, and yielded an agricultural surplus which in turn provided the economic basis for a nonagricultural urban population living by trade and manufacture.

A large part of the Mediterranean area, however, cannot be irrigated; for example, the slopes of hills, high terraces, or plains too far from the sources of water. In the deserts such lands are lost to cultivation, but in the regions of Group III winter crops or perennial crops can be raised by dry-farming methods. Even in ancient times the unirrigated crops played a very important part in the agricultural scheme, many hill slopes having been terraced for vineyards or covered with orchards of olives and figs (Fig. 42).

Generally an advance in the methods of living in an area, far from emancipating man from his physical surroundings, makes closer and closer adjustment to those surroundings necessary. For example, the



Fenno Jacobs from Three Lions

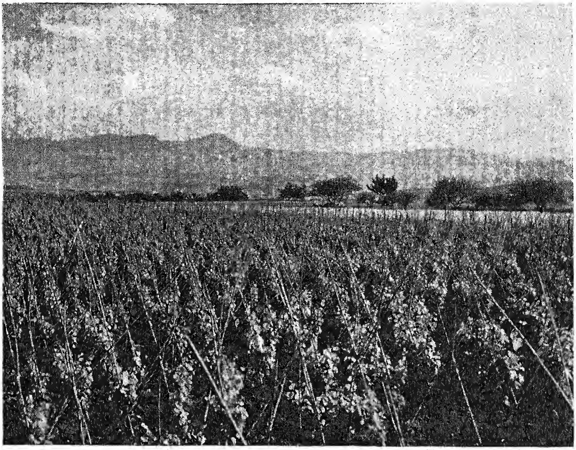
FIG. 42. *Hill slopes terraced for orchards near Florence, Italy*

native gardens of the tropical forest lands, with their mixed crops, are located not on any one type of soil nor any one type of surface, but on a variety of areas wherever they can be reached easily from a village. Only a general and rudimentary adjustment can be observed between the patterns of settlement and the gross features of the land. The contrast with the densely populated rice lands is very great, for here population and settlement patterns correspond closely to the areas most suitable for the production of rice.

In the Mediterranean Basin the culture includes the production of a greater variety of crops, and consequently the adjustments are more intricate. Outside the irrigated tracts the areas of superior soil are generally planted to wheat year after year. The rich alluvial lands of the valleys, terraces, and deltas which are not irrigated, or those especially fertile soils produced by the weathering of old lava flows (which in this part of the world contain minerals to produce an exceptionally fertile soil), are the most favorable sites for wheat. Dry-farming methods have been applied here since ancient times. The crop is planted in the fall after the first rains have moistened the soil, and is harvested the following June during the hot, dry weather of that season, which is so favorable for the best ripening and cutting of wheat. During the summer months the fields lie fallow—not untouched, but plowed and frequently harrowed to keep the surface layer so pulverized that every bit of moisture is preserved.

A very large proportion of the Mediterranean Basin, even of the lowlands, is composed of sandy and gravelly soils which are too porous to support irrigation. These are used for the production of barley and various legumes. The large barley acreage of the Mediterranean countries is evidence of the poor quality of much of the soil.

The vineyards and orchards are generally located on the hill slopes or alluvial fans, the vineyards occupying the best lands. Because of the high yields per acre of the vine, and especially because of the great value of the wine manufactured from this crop, a very intensive form of cultivation can be supported. The vineyards are generally on terraced slopes, and the soil is plowed, harrowed, and manured many times during the year. In the drier and hotter sections the vines are laid on the ground, sometimes in pits about ten inches deep, so that



Fenno Jacobs from Three Lions

FIG. 43. *One of the many fine vineyards in the Mediterranean Basin*

evaporation by the high summer winds is reduced. Only in the cooler, rainier sections are the vines raised on trellises or festooned in the branches of trees. The fox in Aesop's fable, living on the Aegean shores of Asia Minor, was surprised and greatly annoyed to find the grapes hanging beyond his reach, for he was accustomed to finding the luscious bunches lying on the ground (Fig. 43).

The vineyards are also usually placed on the southern sides of the hills, where exposure to the sun produces a superior flavor in the fruit. However, this is not a universal practice, for in some of the drier sections the northern exposure is preferred in order to avoid the very high evaporation during the sunny days in summer. In the regions poleward of this group, where late spring frosts may do great damage to the buds, the placing of vineyards and orchards on the northern slopes or near large water bodies is usual, in order to delay the blossoming until after the danger of frost is passed.

Orchards of olives and figs occupy the less favorable hilly and alluvial sites. Both olive and fig trees are native members of the broadleaf evergreen forest and are well adjusted to existence on the dry, rocky hillsides with only a thin soil mantle.[1]

Pasture Lands. In a region of such intensive agricultural occupance there is little room left for the pasturage of domestic animals. However, two kinds of sites, being unsuited to agriculture, are available for pasture. The first of these is found in the poorly drained, marshy areas of the lowlands,—just the places which peoples of an Oriental culture would have seized most eagerly for rice production. Marshes are found on the lower parts of delta plains or alluvial fans, on the wet spots in the centers of the sink depressions of karst areas, or in the lagoons back of the sand bars along the low coasts. In all such places a rich growth of grasses is available at all times of the year. The very small area of such sites in lands so densely populated leads to an intensive use. Dairy cattle—very uncommon in the regions of this group—are found characteristically in these rare places. An outstanding example of this development is the important modern dairy district of the Maremma coast of Tuscany, near Grosseto (Fig. 44).

Another of these mediterranean pasture sites is found in the neighboring high mountains, where temperatures are too cool for the olives and figs or where the slopes are too steep. Sheep and goats are the animals most commonly found in such places, and these are generally driven up into the mountains during the summer and brought down again to the lowlands for the winter season. This characteristic use of mountain areas will be discussed more fully in the chapter on mountains (Group VIII). In the hilly parts of the Mediterranean region, especially in drier areas, during centuries of human settlement the overgrazing of forested or brush-covered surfaces by sheep and goats has killed off the original vegetation cover and exposed the land to serious erosion. Erosion of this sort not only destroys land which might be used for grazing or even for orchards and vineyards, but also increases the floods and lengthens the periods of low water in the streams drain-

[1]See, however, the description of the intensively utilized agricultural land in the Balearic Islands in J. Brunhes, *Human Geography* (Chicago, 1920), pp. 500–513.

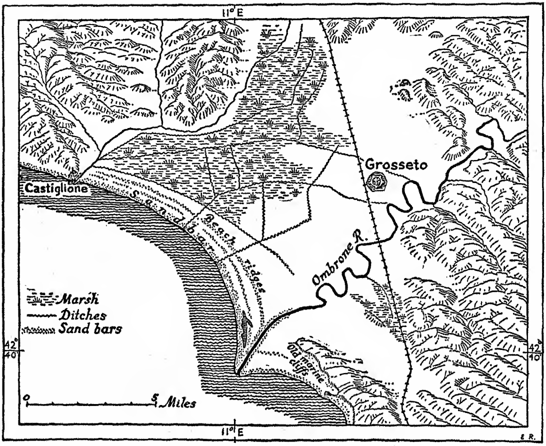


FIG. 44. *A portion of the Maremma coast of Tuscany—a bar and lagoon coast.* (From O. Marinelli, *Atlante dei Tipi Geografici*, Firenze, 1922)

ing to the bordering lowlands. Many parts of these regions have been seriously affected by soil erosion so that the number of people that can be supported in them has been considerably decreased since ancient times. The hilly land of Palestine is a noteworthy example. Only at great cost can the Jewish and Arab farmers rebuild the land.

The Use of the Sea. For various reasons the inhabitants of these lands turn to the sea. The many harbors and islands of the Aegean formed, as we have said, the cradle of ancient navigation. Then, not only did the growing population on the small plains around the Mediterranean Sea cause a rise of oversea trade, but also the abundance of fish provided a very important supplement to the agricultural products. Since ancient times, therefore, the Mediterranean peoples have made use of the sea as a highway and as a source of food.

The Population Problem of Italy. Italy as a whole is one of the countries of Europe which faces a serious population problem. Its population in 1940 was about 44,200,000; but by 1970 it is estimated that the total number will have risen almost to 50,000,000. Not all of Italy is within the area of Group III. The Po Valley is a region of adequate rainfall lying wholly in Group IV; north of that region Italy includes also certain areas of high mountains. In northern Italy are the large cities and industrial populations where large-scale manufacturing and commerce have widened the economic horizons and raised the general standard of living. The rest of Italy, however, remains largely agricultural, and it is in this area that the problem of population is most acute.

The fact is that southern Italy is occupied by too many people; too many, that is, so long as the economy is essentially rural. The average farmer works on a farm which is too small to provide his family with more than a meager living. Because it is so small, and often divided into separate parcels of land in different locations, he cannot accumulate any surplus capital with which to buy machinery or with which to improve the yield per acre of his land. Much of the good land, moreover, is in large private estates, where commercial crops are raised by tenant workers. Projects for breaking up large estates or for draining previously unused marshlands have not provided new farms at a fast enough rate to keep pace with the growing number of farmers. The result is widespread poverty and unrest. The Fascist regime used population pressure as an excuse for territorial conquest, yet the fact remains that Italy's former colonies could never have provided an outlet for increasing numbers of people. Libya, as we have seen, is not suitable for any large number of new settlers; and Ethiopia, because it is mountainous and already occupied, could scarcely offer an outlet for any large numbers. Also, Italy's experience, when millions of Italians emigrated to the Americas, between 1890 and 1914, was that the total population at home was not reduced.

The only program for Italy which offers much hope is to extend the development of industries into the southern part of the country. Manufacturing industries could provide employment and, at the least, an improvement in living conditions for the large number of rural people

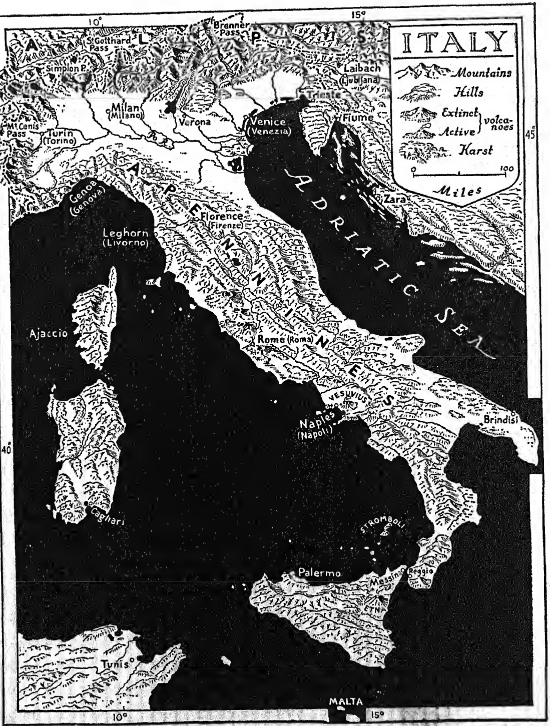


Fig. 45. *Italy*

now condemned to hopeless poverty. But even the development of manufacturing will be able to bring only temporary relief unless the rate of population increase is lowered, as, indeed, it has already been lowered in the urban centers of the Po Valley.

The Palestine Problem. Palestine is on the dry-land margin. Most of the country lies within arid regions which are suitable only for a scanty population of herders, or for oasis people clustered at the few sources of water. The part of Palestine which attracts international attention is the part where Jewish colonists have been established in the midst of large Arab majorities. This part of Palestine, along the Mediterranean coast and extending inland to the hills beyond the Jordan Valley, is one of the marginal, drier parts of Group III. It is generally deficient in rainfall, but what rain it receives comes during the winter months. Moreover, it has no source of water for a large increase of the irrigated area. The Jordan is relatively small and flows for much of its course through a narrow gorge. The development of irrigation in this part of Palestine would be very expensive. Add to all these physical handicaps the fact that much of the hilly country, which might be suitable for orchards or vineyards, has been destroyed by overgrazing, and one gets a clear picture of a land poorly suited to agricultural settlement (Fig. 46).

Yet Palestine remains the "promised land" for the harried Jews of Europe. In the ceremonial language of the Jewish religion the Jewish people have told themselves for centuries that they should return to Jerusalem. But Palestine has belonged to the Arabs for thousands of years and is one of the more densely populated parts of the Moslem world. And Palestine occupies a highly strategic position with respect to the Suez Canal and the "life line" of the British Commonwealth. The situation is charged with religious and political tensions, so great that a calm discussion of the economic realities is almost impossible.

The population density in the settled portion of Palestine is already high. In 1940 it was well over 300 persons per square mile. Furthermore, a large proportion of its population is young, so that a high rate of increase, even without any more immigrants, can be expected. Within Palestine there is a tendency toward the internal rearrangement of people: a movement, including all elements of the population (Moslem, Jewish, and Christian), away from the poorer areas and toward the centers of enlarged economic opportunity. These centers are the new Jewish cities, especially Tel-Aviv. The total population in 1940, excluding the desert area, was estimated to be 1,478,000, of whom about 60 per

cent were Moslems, and about 31 per cent were Jews. It is estimated that by 1970, without further immigration, the population will be about 3,000,000, of which about 63 per cent will be Moslem and 29 per cent will be Jewish.

There is, of course, no limit to the population that can be supported in this region if the costs are met by outside assistance. Analyzed in terms of a process of settlement which forms its own workable economy, however, it is obvious that Palestine cannot depend on farming alone. Here, as in Italy, manufacturing industries must be developed, and international commerce must be built to support them. Because of the nature of the local resources, raw materials must be imported, and the products must be exported to distant markets. Entirely new currents of international commerce must be built up where no such currents exist today. There is no insuperable reason why such commerce may not be established provided sufficient capital is available; but such an industrialized Palestine could scarcely survive in a world of restricted international trade or in a world at war, for its urban population would be largely dependent on imported supplies of basic necessities.

Occupance of the North American Regions. The analogous regions of Group III in other parts of the world have certain elements of remarkable similarity to these ancient Mediterranean lands, but there are also certain essential differences. The striking resemblance of most of the widely scattered parts of this group as regards physical background has been the subject of much comment, although the bare white limestone surfaces of the Old World karst lands have no counterparts in the other areas of Group III. The greatest differences, perhaps, are in the forms of the occupance. In the first place the North American regions and, especially, the Southern Hemisphere regions are relatively remote and isolated. As a result the settlement is neither so dense nor so intimately adjusted to the land as in the Old World. The Mediterranean countries carry the record of long periods of occupance; in contrast some of the analogous regions exhibit the most modern phases of Occidental occupance, unencumbered by the relict forms of previous settlement. The native inhabitants of these other parts of Group III possessed simple, primitive cultures, with none of what we think of as the char-

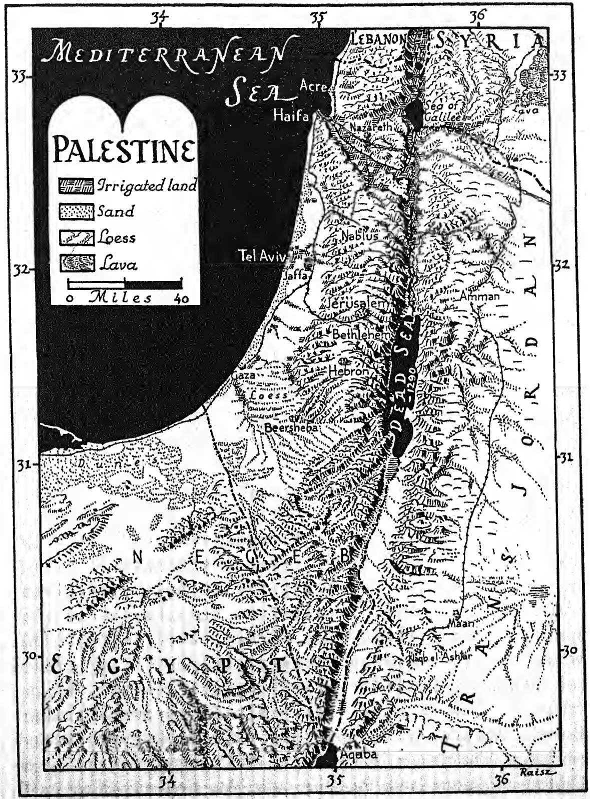


FIG. 46. *Palestine*

acteristic mediterranean crops or techniques. They maintained a poor existence in a land which provided them with only meager resources, and colonization by Europeans or Americans almost entirely eliminated their traces.

The first European penetration of California came in the late eighteenth century. The first pioneers were the missionaries who established mission stations along the route from the centers of Spanish settlement in Mexico northward along the Pacific coast as far as San Francisco (Fig. 34). At the missions the scanty Indian population was gathered together, taught Christianity, and instructed in the methods of agriculture. The crops introduced were those already well known to the Spaniards: wheat, barley, figs, olives, and the vine. Cattle were also introduced, and the Indians were taught to care for domestic animals. With the establishment of Mexico's independence and the removal of the mission system during the first quarter of the nineteenth century, the practice of agriculture in California declined. The land was given in large tracts to colonists from Mexico, but the only use to which it could be put with profit was cattle-ranching; the chief products were hides, tallow, and salt beef. When the gold rush began shortly after the whole area was annexed by the United States, the incoming flood of new settlers could not find enough local supplies of food to maintain themselves.

The period since the middle of the last century has been marked by a series of forms of land use, each motivated by the search for speculative profits. Each speculative development was applied to a different part of the land, and, once established, has been continued even after speculative profits could no longer be made. Between 1860 and 1870 wheat farming was started on large areas, chiefly in the Central Valley and mostly unirrigated. Between 1870 and 1880 there was a big development of sheep-herding with wool as the commercial product. Between 1880 and 1890 vast areas were laid out for fruit orchards and vineyards. The decade 1890–1900 saw the beginnings of the use of California's pasture lands for dairy cattle. More recently many small localities have come to specialize in the production of certain vegetables to be sold not only in the cities of the west coast, but also in the east (Fig. 47).

© Screen Traveler from Gendreau

FIG. 47. *Loading celery for market on a Central Valley farm*

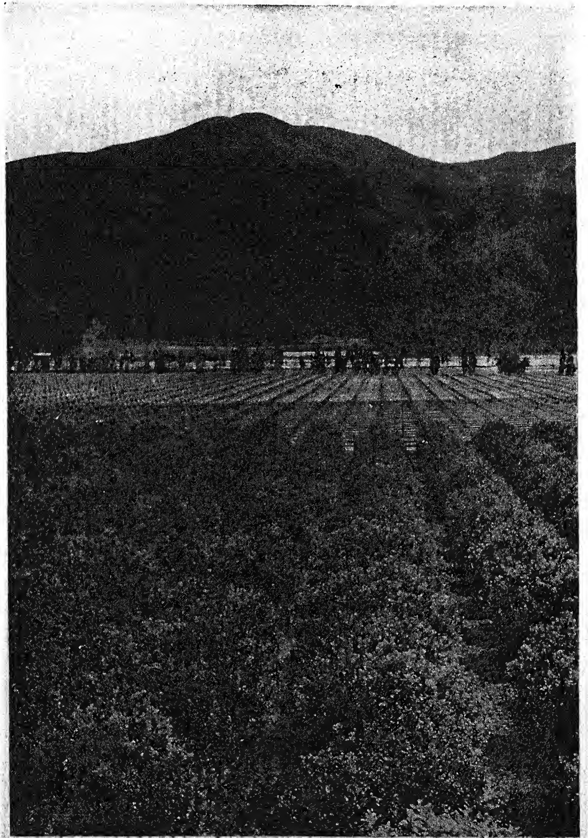
As these developments appeared one after the other, there was a steady increase in the use of water for summer irrigation. At first the winter runoff was permitted to escape through the rivers to the sea. But now it is widely recognized that a more efficient use of water is needed: that there must be dams and reservoirs to store the winter rain, and a co-ordinated system of canals to spread this water over the lowland farms in the summer. The Central Valley project, now in process of development, will greatly increase the supply of water for use in summer, and will add both new areas of summer crops and a greater volume of production of such crops from older areas.

The present agricultural localizations in California are notably distinct. Where conditions of climate, soil, or water supply are especially favorable for a certain crop, the result—in an economy of relatively unrestricted trade and low-cost transportation—is a concentration of production in the best-suited areas. Today citrus groves cover the irrigated alluvial fans around the border of the Los Angeles lowland

(Fig 48). Vineyards are found along the alluvial fans of the Sierra Nevada from Fresno northward, and in valleys of the coastal region north of San Francisco. From the Santa Clara Valley, south of San Francisco Bay, comes a large part of the world's supply of prunes. Almost all the lima beans of the United States are grown without irrigation in the belt of light fogs along the coast (this is to the south of the area noted on Figure 34 as having almost continuous summer fogs, Csbn). In addition, there are areas devoted to barley, which has now greatly surpassed wheat in this region; to rice, chiefly in the lower part of the Central Valley between Sacramento and Stockton; and to sugar beets and cotton.

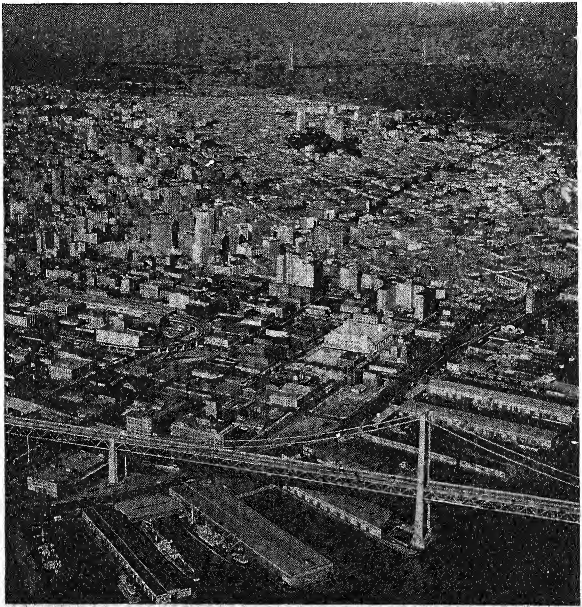
In California there is no such problem of overpopulation as complicates the process of settlement in parts of the Old World. The rural population of California is densest in the lowland east of Los Angeles. Here the figure is between 75 and 100 per square mile. Over most of the Central Valley, except for the section between Stockton and Sacramento, the density is less than 25 per square mile. In the San Francisco Bay region it is between 25 and 50 per square mile. Los Angeles and San Francisco are among the large commercial and industrial cities of the United States. Especially in the cities around San Francisco Bay there has been a considerable development of manufacturing industry (Fig. 49).

Occupance of the Southern Hemisphere Regions. In many ways the part of Chile between Valparaiso and Concepción is remarkably similar to California The arrangement of its surface features (Fig. 39) recalls the essential lineaments of its North American counterpart. But Middle Chile has had a very different kind of occupance. There the land was divided early in the colonial period into vast private estates, and this form of land tenure persists to the present time. Furthermore, Chile has never had access to a large market in which it could dispose of surplus agricultural production in exchange for other things. As a result there are fewer agricultural localizations in Chile than in California. The chief use of the land is for pasture, or for the raising of feed crops such as alfalfa. The chief food grain is wheat. There are also considerable acreages of vineyards, olives, and other mediterranean fruits. But much the same combination of crops is repeated on each



James Sawders

Fig. 48. *Citrus groves bordering the Los Angeles lowland*



Fairchild Aerial Surveys, Inc.

Fig. 49. *An airview of San Francisco*

estate. The better lands of the valley bottom are used for alfalfa and the poorer lands for wheat—a reflection of the predominant interest of the Chilean landowners in stock-raising; vineyards are on the slopes of the alluvial fans or on wetter hillsides; the bordering hills and mountains are mostly used only for summer pasture. The density of rural population in this part of Middle Chile is generally higher than that of comparable parts of California. In the vicinity of Santiago there are over 400 people per square mile. Poverty among the people who do the agricultural work is widespread.

Typical mediterranean agriculture has made its appearance in only a small area of South Africa and Australia. In the region of Group III around Cape Town (Plate 14 and Fig. 12) are found the usual crop combinations. In Australia, settlement is still in an early stage. Around Adelaide, and inland from Perth (Plate 20 and Fig. 50), pioneer colonists are engaged in clearing the broadleaf evergreen forest and maquis and laying out new farms. The chief pioneer crop is wheat.

Conclusion

Stages of Settlement. It is possible, now, to recognize certain rather distinct stages in the settlement of an area by people of Western culture. The *pioneer stage* is characterized by a scattered or patchy distribution of settlements in the midst of undeveloped lands. Usually these first clearings (if they are in a forest) are governed in their location and arrangement by the ease of access to a main artery of travel. The first settlements in Rhodesia, in southeastern Brazil, or in southwestern Australia furnish examples of this pattern of arrangement. As settlement progresses and more people come into an area, the skeleton, so closely articulated to the main lines of travel, is filled in, and numerous branch lines (roads or railroads) link these new settlements with the main arteries. This may be called the *stage of elaboration*, when the outline of settlement is filled in and begins to show a closer and closer relationship to the underlying qualities of the land. Thus, in the pioneer stage, whatever governs the position of the highway also governs the general arrangement of the settlements; but during the stage of elaboration the occupance tends first to adjust itself to the more conspicuous features of the terrain. As settlement continues and transportation is made easier, there is more and more of a tendency toward concentration on the best lands, and, moreover, toward the intimate adjustment of the various forms of land use to the varying qualities of the sites. Adjustment becomes nicer and more detailed; each significant change in the character of the soil, the surface, the drainage, or any other feature of the land is reflected by a change in the way that land is used. This may be called the *climax* of settlement, and is well illustrated by many

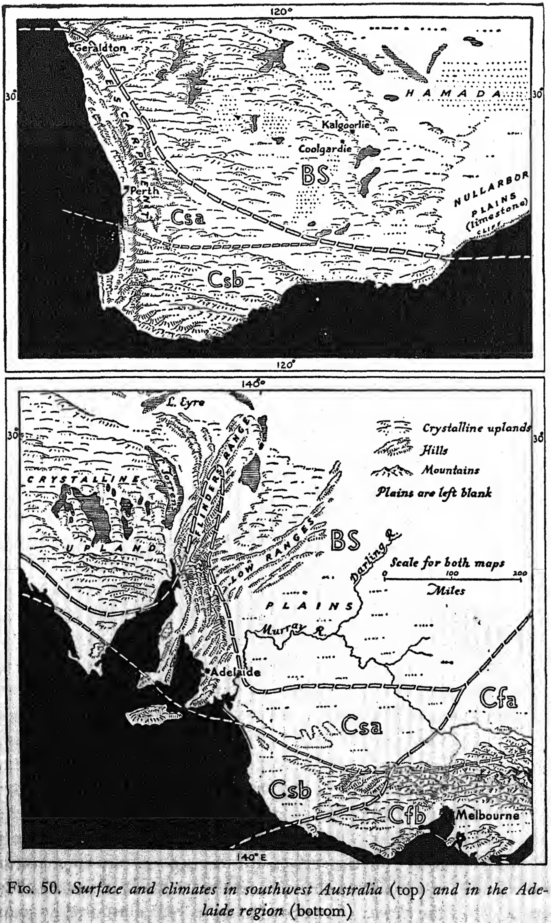


FIG. 50. *Surface and climates in southwest Australia* (top) *and in the Adelaide region* (bottom)

of the more densely populated regions of the Mediterranean Basin. Here, even in ancient times, each crop had its own peculiar type of site, and even the wet marshes of the coastal lagoons were utilized as intensively as possible.

There is, of course, nothing inevitable about such a sequence of stages. In some cases areas may stagnate almost indefinitely in the stage of elaboration. In others a region may advance rapidly from a pioneer stage to the development of a number of small areas of climax, such as the intimately adjusted Fresno raisin district in the midst of a territory where the settlement pattern is still far back in the process of elaboration. In still others, which have reached a climax, events may cause retrogression. Wars, conquests, epidemics, inventions, political changes, the imposition of tariff barriers, or the development of new currents of trade may cause the decline of an area which had once reached a climax.

There are many examples of decline from an earlier climax in the regions which border the Mediterranean Sea. In the course of the centuries since the flowering of the cultures in this area, the traditions so carefully nurtured were for a time lost to sight, preserved in isolated monasteries or in the writings of Arab scholars. Many hundreds of years later these concepts and techniques were rediscovered and, in the hands of a different people, led with cumulative force to the development of the machine culture as we know it today. The focus of the Occidental world is no longer on the Mediterranean Basin: the nuclear areas of Western culture are now in the mixed forest lands, on the borders of the North Sea in Europe, and on the Atlantic coast of northeastern United States.

GROUP IV

THE MID-LATITUDE MIXED FOREST LANDS

Nearly two fifths of the world's population lives in the mid-latitude mixed forest lands. The concentration of people in the regions of Group IV, which together comprise only 7 per cent of the world's land area, is one of the most striking facts of world geography. Furthermore, within these lands are found the centers of two of the world's chief cultures—the Oriental and the Occidental. The industrial society, one of the major divisions of Occidental culture, had its beginnings around the shores of the North Sea in Europe and its greatest development in the eastern part of North America. The Chinese branch of Oriental culture had its origins in the middle valley of the Hwang, and spread into the once forested regions of the Yangtze and southeast China. Today the population of these regions, and of their Southern Hemisphere counterparts, includes 39 per cent of mankind.

The fundamental reasons for the distribution of people have been debated since man first became conscious of his place in the world. The writers of ancient Greece first presented the argument for climatic control: that the torrid lands to the south were too hot and the frigid lands to the north were too cold for civilized men to inhabit. Since that time, however, the centers of Western culture have moved northward into those regions which the ancient Greeks considered fit only for barbarians, and the climatic argument has been suitably revised. A very great deal of semi-popular writing on the question of racial qualities and distribution has served to obscure rather than to illuminate the facts. Theories as to the close dependence of man's civilizations on climatic stimulus, on the superior qualities of certain races, or on other single factors have been presented, perhaps with too little regard for contradictory evidence. Actually the explanation of the present distribution of people in the world is extremely complex and requires an understanding of a variety of factors. So complex are the forces at work in human society that adequate data to measure them are not available, and a discussion of the whole broad problem on a world level requires frequent excursions into the realm of assumptions, hy-

potheses, and plausible but unproved suggestions. Such excursions can be stimulating and profitable, but not necessarily successful in reaching anything like complete understanding.[1]

Basic Factors. An understanding of human life in its relation to the earth must be based on a study of the interaction of three basic factors or conditions. These are the biological inheritance, the physical environment, and the culture. The explanation of the arrangement of people on the earth involves all three.

Biological inheritance is, perhaps, the factor concerning which there is the largest volume of speculation and the least volume of proved data. A universal characteristic of mankind is that each self-conscious human group or society has explained its pre-eminence on the basis of racial superiority. The great Christian principle that all men are brothers has never been given wide popular support, even among Christians. The fact that this principle expresses what scientists are step by step proving to be a fundamental truth does not alter the fact that the belief in racial superiority has been a basic motivation throughout the long course of human history.

Anthropologists have not yet agreed on the criteria by which the races of mankind might be distinguished. They are agreed that the popular division of man into races based on skin color is unimportant. The fact is that skin color is only one superficial item, and it can be demonstrated that no special group of traits or characteristics is universally associated with particular shades of color. Attempts to classify races by head shape also fail to produce clearly defined groups of associated traits. In other words, there are all kinds of people in whatever racial group can be defined. There are no "pure" races; all mankind is mongrel. It might even be more illuminating to divide mankind into short and fat types and tall and thin types than into people of different colors or head shapes.

But this does not mean that biological inheritance is of no significance. It only means that the methods used to classify and measure such inheritance have not yet been successfully developed. There is no doubt that certain human groups show a preponderance of special

[1]For example, see Ellsworth Huntington, *The Mainsprings of Civilization*, New York, 1945.

characteristics. It seems likely that groups with marked characteristics which distinguish them from other people are developed in the course of migration or hardship, through the mechanism of the selection of individuals possessing these characteristics. For example, during the many years of the colonization of North America by Europeans there was a process of selection at work—a selection of those people who had the physical and mental qualities that would lead them to give up familiar ways of living to try something new or which would permit them to flee from problems they could not solve at home with the hope that somewhere else it would be easier. Such a process of selection is not a simple thing and has never been carefully described or measured; but that it has been operative cannot be denied. Its significance in determining the attitudes and objectives of the American people cannot be evaluated, but it can be recognized.

The physical environment, on the other hand, can be described and measured with considerable accuracy. To be sure, the evaluation of its significance in terms of human action cannot be made until the other basic factors can be weighed in the same scales. But that the earth conditions which we include in the term "the land" are important in an understanding of the arrangement of people in the world must not be overlooked. The physical environment does not appear to be a positive force, impelling certain kinds of development among human societies and denying other kinds. Rather it remains neutral and indifferent so far as human problems are concerned. Human societies must adjust to the qualities of the land they occupy, but the method of adjustment is determined by forces within the society, biological and cultural. At the extremes there are lands too dry, or too wet, or too cold for human settlement; but the limits which define such areas are, as we have seen, flexible ones. The physical conditions which are critical in determining the distribution of any one human society are made critical by the attitudes, objectives, and technical abilities of the people themselves. In other words, the significance of the elements of the land is determined by the culture of the people.

Human culture is another basic factor which does not lend itself to exact measurement or definition. Yet the methods of describing culture and analyzing its significance have been developed far beyond the

point reached in the evaluation of the biological inheritance of man. When we focus attention not on mankind as a whole but on specific human groups, the importance of the traditional ways of living—the systems of values, the religious beliefs, the customary ways of securing food, clothing, and shelter, the familiar diet, and the sum total of technical knowledge—these qualities of the culture are fundamental to an understanding of why people react to a certain physical environment the way they do. As we pointed out in the introduction to this book, conservatism, resistance to change, and the maintenance of old, established ways are more descriptive of each human civilization than are progress, change, and evolution. Change usually takes place suddenly, either by conquest from outside, or by some spectacular development within the culture. Each change ushers in a new period of sequent occupance in a region, and the new patterns of human life are superimposed on the older patterns—the features of the physical land take on a new significance in terms of human habitability.

The distribution of mankind in the world is the result of the interplay of all these basic factors. It is believed that the human race had its beginnings somewhere in central Asia, near the place where the world's mountain systems are joined together; and from this heartland mankind has migrated in three directions along the three land arms. But the details of this movement are lost in the obscurity of the ages before the beginning of written history. At the beginning of the period for which we have documentary evidence of human events, man was spread over the earth—he had reached the farthest end of the three land peninsulas. His earliest civilizations appeared in diverse places: in the valleys of exotic rivers such as the Tigris-Euphrates, the Nile, and the Indus; in well-watered valleys such as the Wei in China; in what is now a tropical lowland in southern Mexico and Guatemala; and in the high basins of the Andes in Peru and Bolivia. The concentration of people in the forests of the middle latitudes did not make its appearance until recently in human history. In China, to be sure, the clearing of the forest took place many thousands of years ago. But the clearing of the forest in Europe has taken place largely since the eleventh century A.D.; and the settlement of the North American mixed forest regions is much more recent.

The climatic features shared in common by all the regions of Group IV are those of adequate but not excessive moisture, moderate temperature, and weather variability. From the point of view of the kind of farming practiced by Europeans, these lands have definite advantages over other parts of the world. The land offers difficulties to the establishment of dense populations where it is too dry, or too wet, or too cold; in the regions of Group IV none of these extremes is encountered.

But there is more to the story of man's concentration in these regions than simply adjustment to physical suitability for one kind of farming. The fact is that the one basic cause of human migration is the search for greater economic opportunity. The largest movements of people in the modern world take place toward regions where the chances of making a better living are greatest. The existence of an area of larger economic opportunity is determined not by climate alone, nor by the total quality of the land, but by people with peculiar biological inheritance and cultural tradition. The industrial society in recent times has offered such opportunities on a scale never before experienced, and to the centers of this society have come larger and larger numbers of people. That these centers are in an area suitable for mixed farming may be irrelevant. The greatest movement of people in history, the settlement of North America, was directed to an area where a people in process of developing the industrial way of living were also engaged in the process of occupying and exploiting lands essentially empty of previous inhabitants and remarkably well-endowed with the kinds of resources demanded by the new society. The present distribution of people, then, is a result of complex movements and forces, many of which are still not fully understood. Our study of the causes of population distribution will raise more problems than the social sciences, at their present stage, can answer.

Nevertheless, the arrangement of people on the land is of fundamental significance in connection with the great economic, political, and social problems of our time. It is essential to describe the known relationships and to point out the meaning of the differences from place to place. And since every human society must form workable connections with the land, even if the land is not a positive force in deter-

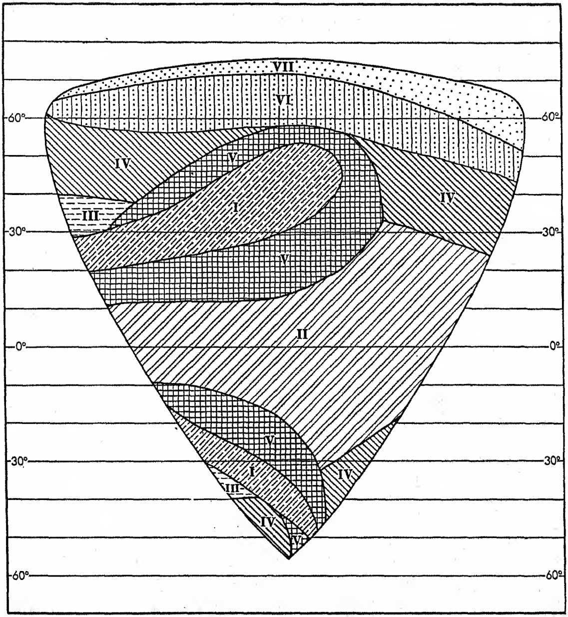
mining what those connections are to be, it is essential to describe the different kinds of land and to understand the size, shape, and position of each as a part of the world pattern.

The Land

VEGETATION AND CLIMATE

The position of the mid-latitude mixed forest lands in the world pattern is best understood by considering the world as a whole, which we are now ready to do. We find that there are four major kinds of vegetation: forests, grasslands, deserts, and tundras. Between these major kinds lies a variety of transitions. In fact, the major types themselves represent transition, on the one hand from the very dry lands, where only xerophytic vegetation can maintain a precarious existence, to the rainy lands where luxuriant forests cover the earth's surface; and on the other hand from the hot regions of the low latitudes to the cold tundras and ice deserts of the high latitudes or the high altitudes.

The pattern of arrangement of these major kinds of vegetation on the earth is a reflection of the underlying pattern of climatic features. As we have seen in the previous discussion of the first three groups, each occupies a characteristic position on each continent. The general distribution of deserts, for example, has been described as follows: they are found on the west coasts of all the continents between 20° and 30° N. and S., and they bend inland and poleward in the continental interiors to about latitude 55°. In specific detail on each continent the arrangement of the dry lands is somewhat different; for the general description of the desert location takes into account only four of the controls of climate, namely latitude, differences of land and water, prevailing winds, and ocean currents. It leaves out the complicating details resulting from specific continental shape and from the arrangement of mountains. These two elements force the generalized pattern of dry-land distribution into the particular pattern to be observed on each continent. But however distorted the particular pattern, it is obviously similar in broad outline to the generalized pattern.



I The Dry Lands
II The Tropical Forest Lands
III The Mediterranean Lands
IV The Mid-Latitude Mixed Forest Lands
V The Grasslands
VI The Boreal Forest Lands
VII The Polar Lands

FIG. 51. *Generalized continent with pattern of natural vegetation*

On Fig. 51 a generalized continent is shown, bordered on all sides by ocean. The outline of the continent is smoothed, but it preserves the general shape of all the land masses in that it is widest in higher middle latitudes of the Northern Hemisphere and tapers toward the south. Except for Antarctica, which is wholly within the south polar desert, the continent which extends farthest south reaches about lati-

tude 55°; therefore the generalized continent is drawn to this latitude. On this outline the broad patterns of world distribution can be shown.

We can observe the relative position on the continents of the major kinds of vegetation. The position of the dry lands agrees with the general description of desert distribution given above. Surrounding the deserts and conforming to the general pattern of desert distribution lie the grasslands—essentially transitional between places where moisture is abundant and places where it is deficient. The forests of the low latitudes occupy the whole width of the continents for about 10° on either side of the equator, except where highlands, omitted from the generalized continental outline, interrupt. On the continental east coasts, as we have seen, the tropical forests extend poleward to the margins of the low latitudes. Also, in the last chapter we found that the mediterranean forests occupy the continental west coasts just poleward of the deserts.

It is now time to complete this general picture of forest distribution. Along the continental west coasts the forest continues poleward as far as temperature conditions permit tree growth. Where mountains border the sea, as in Norway, British Columbia and Alaska, southern Chile, or New Zealand, the forest is limited to a narrow strip along the coast and the lower mountain slopes; but in Europe, south of the Baltic, the forest extends inland and crosses the whole continent of Eurasia, north of the deserts and grasslands, to the east coast. Similarly, in Canada, east of the mountains, the forest lies in a continuous belt between the deserts and grasslands of the continental interior and the tundra of the high latitudes. On the east coasts of the Northern Hemisphere the forest continues into middle latitudes and here also extends as far poleward as tree growth is possible. Thus the middle latitudes are forested on the eastern and western sides of the continents, and where the land masses reach sufficiently high latitudes they are forest-covered from ocean to ocean between, roughly, latitude 50° and the polar boundary. The differences observed on Fig. 51 in the Southern Hemisphere, where, for example, the forest is interrupted on the east coast beyond latitude 40°, are the result of the decreasing width of land area with increasing latitude, and the very wide area of cold ocean water which, under these circumstances, lies off the east coast in higher middle latitudes.

WIB Photo

FIG. 52. *A coniferous forest in Western Canada*

The forests are of various kinds. They may be evergreen or deciduous, or a combination of these; they may be composed of broadleaf trees or conifers or of a mixture of these types. In general, the tropical forests are composed of broadleaf trees, evergreen except in the regions having a pronounced dry season. The mediterranean forests are also chiefly broadleaf and evergreen. In general, conifers are pushed out by the competition of broadleaf species, and can therefore survive only where the climate or soil is unfavorable for the latter. The northern, or boreal, forests which cover the whole expanse of the higher middle latitudes of Eurasia and North America, where the winters are long and severe, are mostly coniferous and evergreen (Fig. 52).

The mid-latitude mixed forests, composed of both broadleaf and conifer, are transitional between these two extremes. They occupy two distinct positions in the generalized continental pattern in the Northern Hemisphere: east of the dry interior, between, roughly, latitudes

25° and 45°; and west of the dry interior but poleward of the mediterranean forests of Group III, between, roughly, latitudes 40° and 60°. In the Southern Hemisphere, the mid-latitude mixed forest is also separated. It occurs on the eastern side between latitudes 25° and 40°, where it borders the grasslands. On the western side it extends from about latitude 40° to the southernmost point of land.

The Pattern of Climates. These major kinds of natural vegetation reflect the underlying pattern of world climates. In previous chapters we have discussed certain aspects of the climatic pattern. We have described the various factors which determine rainfall effectiveness, and we have shown the relationship between rainfall and temperature on the one hand, and on the other, the four basic controls of climate: latitude, land and water distribution, prevailing winds, and ocean currents. It is now time to summarize the effect of these controls on the pattern of climates.

The distribution of air temperature on the earth's surface is determined in general by differences in latitude and by the contrasts between land and water. For reasons which are set forth in Appendix B, the heat received from the sun at the earth's surface is greatest in the low latitudes and decreases toward the high latitudes. If the earth's surface were all land or all water, there would be a simple arrangement of temperature by latitude, with the highest temperatures along the equator. But at any one latitude, land areas heat up much faster when the sun is high, and cool off much more rapidly when the sun is low, than do neighboring water bodies. For this reason, at the same latitude the land becomes warmer than the water in summer and cooler in winter. Continental climates are those which have great temperature differences between summer and winter; marine climates are more moderate throughout the year. Fig. 53 shows the generalized position of two lines of equal temperature (isotherms) crossing the same continent shown in the previous figure (Fig. 51). The solid line is a winter isotherm—a line connecting places which have a certain average temperature in the coldest month (26.6°). Because the land is colder than the water in winter, this isotherm bends equatorward as it crosses the continent. The dashed line is a summer isotherm, connecting all points

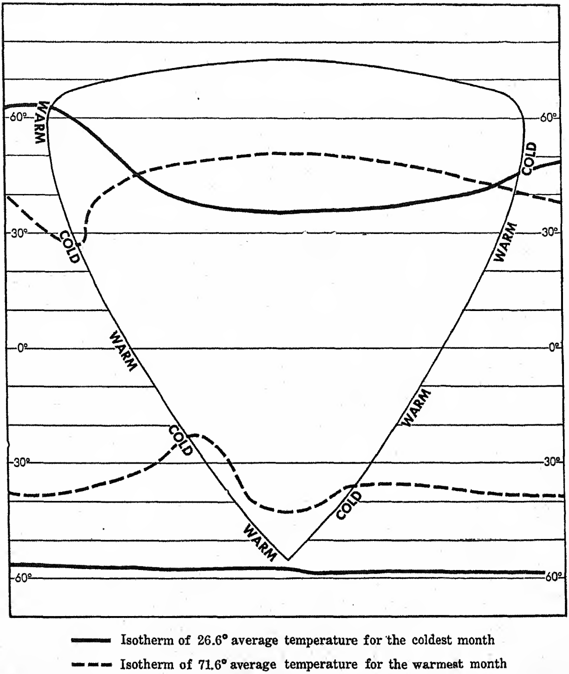


FIG. 53. *Generalized continent with pattern of summer and winter temperatures*

which have a certain average temperature for the warmest month (71.6°). Because the land is warmer than the water in summer, this isotherm bends poleward in crossing the continent. In the Southern Hemisphere the two isotherms do not cross each other as they do in the Northern Hemisphere. The small land area in higher middle latitudes makes the development of very cold winters impossible. The

winter isotherm runs east and west just about as it would do if the world were all water.

The two isotherms in the Northern Hemisphere, however, are not arranged symmetrically on the continents. The winter isotherm reaches the west coast about latitude 60°; it reaches the east coast, on the other hand, between 40° and 45°. The summer isotherm is pushed far equatorward near the west coast, so that it reaches the land about latitude 30°; it bends sharply poleward on the land, however, and reaches the east coast at about the same latitude as does the winter isotherm—between 40° and 45°. These isotherms are based on the actual distribution in the world of two arbitrarily selected temperatures; but any other winter and summer isotherms would show a similar trend in crossing from water to land.

If the only two controls of temperature were latitude and land-water contrast, the isotherms would not show this peculiar lack of symmetry. They are displaced eastward—so that the maximum difference between summer and winter is east of the center of the continent—because of the prevailing winds and ocean currents.

The world's ocean currents are shown on Plate 23. Within each ocean basin and along the shores of each continent there are similar ocean currents. The position of warm and cold water near the shores is roughly the same in each ocean basin. The relation of ocean temperatures to the temperatures on the east and west coasts of the continents is clear. The summer isotherm bends sharply equatorward because of the very cold water along the west coasts between 35° and 15°. This appears in both hemispheres. The winter isotherm is much farther north on the Northern Hemisphere west coasts than it is on the east coasts in part because the west coasts beyond 40° are bathed by warm water and the east coasts beyond 40° are bathed by cold water.

General Circulation of the Atmosphere. The prevailing winds also contribute to this arrangement of the isotherms. As we have seen, there are three major elements to the world's wind systems. There are the oceanic whirls, the monsoons, and the polar outbursts. The oceanic whirls are so geared together that on their equatorward sides, in the low latitudes, the wind comes generally from the east, and on their

poleward sides, in the middle latitudes, it comes generally from the west. For this reason the moderating effect of the ocean on summer and winter temperature in the middle latitudes extends farther inland from the west coast than from the east coast. In fact, continental conditions extend eastward to cover all but the offshore islands and peninsulas on that side of the continents. This is brought out strikingly by a comparison of the latitude of the big urban centers of Europe and eastern North America. Due west of London, on the eastern coast of North America, lies sparsely populated Labrador. Such northern European cities as Oslo, Stockholm, Helsingfors (Helsinki), and Leningrad lie in the same latitude as southern Greenland or the northern part of Hudson Bay. On the continent of North America, New York and Sitka both have about the same January mean temperature, 30° and 31° respectively; but the warmest month in Sitka is 55°, and in New York it is 73°.

The isotherms, however, tell nothing about rainfall, storminess, and the variability of weather. Rainfall, for reasons described in Appendix B, is caused only when air containing considerable quantities of water vapor is forced to rise and cool. The largest amounts of rising air are found in those places where different currents converge. Along the equator over the oceans, for example, the air moving equatorward in the oceanic whirls of both hemispheres converges. Because the resulting rise involves air which is filled with water vapor picked up over warm ocean water, the rainfall is heavy (Plates 7 and 26). The convergence of the oceanic whirls is strongest on the western sides of the ocean basins; and because the deflective force of the earth's rotation is not felt at all on the equator and only very slightly for about ten degrees on either side of it, the northeast and southeast winds continue, if terrain permits, far into the continental interiors. Heavy rains on the eastern slopes of the Andes come from the indraft of oceanic air which is especially strong from January to May. On the eastern sides of the ocean basins and on the west coasts of the continents there are wedge-shaped areas of calms in which heavy convectional rains occur during and shortly after the passage of the sun over the equator. These are known as the *doldrums*.

Rising air, heavy rains, storminess, and weather variability in the middle latitudes all result from the interaction of the poleward parts

Courtesy of Second Byrd Expedition

FIG. 54. *On the ice-covered continent of Antarctica*

of the oceanic whirls with the equatorward-moving polar outbursts. Cold air accumulates over the snow and ice surfaces of the high-latitude regions, especially over Greenland, the Arctic Ocean, the snow-covered continents in winter, and, more than anywhere else on earth, over the ice-covered continent of Antarctica. At intervals the cold air surges out toward the nearest warm spot. It moves close to the ground, for cold air is heavy, and each outburst takes on much the shape of a drop of water rolling over an inclined surface. As the cold air moves into the relatively warm, light air of the oceanic whirl the latter is forced to rise. Eddies are formed around the edges of the cold air masses, and in the centers of these secondary whirls, or cyclones, air is forced to rise vigorously. Along the cold air fronts there are heavy falls of rain, and sometimes violent winds. Those parts of the world over which cold and warm air masses alternate are the areas of greatest storminess and weather variability (Fig. 54).

Actually the world's stormiest areas are found where warm ocean water is relatively close to centers of cold air accumulation. The stormi-

est part of the world is the higher middle latitudes of the Southern Hemisphere, surrounding the Antarctic Continent. Great storminess is also experienced over the North Atlantic Drift where it passes south and southeast of Greenland; and over the Kuro Siwo where it passes close to the cold Bering Sea and northeast Siberia. Storminess and weather variability, however, extend beyond these maximum zones: the continental coasts both on the west and on the east are very stormy in higher middle latitudes. In winter the cold air masses push equatorward of 40° on the west coasts, and much farther toward the equator on the east coasts, where there are warm ocean currents. The cold air masses that reach western North America come largely from Siberia, the Arctic Ocean, and Alaska; in western Europe, cold air masses come not only from Greenland but also from the continental interior to the northeast. In eastern North America, cold air pours southward from the Arctic Ocean and from Greenland across Canada and the United States. In eastern Asia the very cold area of northeast Siberia is a source of so many polar outbursts that, latitude for latitude, as compared with eastern North America, the winter temperatures of Asia are some ten or twenty degrees lower. The basic cause of the difference is the relative size of Asia and of North America. The temperatures of winter in the continental interior of Asia are much lower than those in the interior of North America.

It is worth noting in passing that the common opinion in the United States concerning the supposed warming effect of the Gulf Stream is erroneous. The fact is that the warmer the water is in the Gulf Stream, the stronger are the cold air masses that move toward it from the higher latitudes. Rising ocean temperatures in the Florida Strait between Florida and Cuba are used by long-range forecasters to predict cold weather and storminess in northeastern United States.

Monsoons and Monsoons. The monsoon is defined as a movement of air from cool places to warm places which for six months goes in one direction and for the other six months goes in the opposite direction. It is produced, as we have seen, by differences in temperature between land and water. The true monsoon is formed where the stream of air continues without interruption. It is found on equatorward-

facing coasts in the low latitudes—a situation which is not shown on the generalized continental outline, but which is one of the specific departures from the generalized outline which gives each continent its unique pattern. On such coasts there is warm ocean water on the equatorward side which supplies air over it with great quantities of moisture. On the land poleward of the equatorward-facing coast, the temperatures are higher than those over the tropical water in summer, but much lower in winter. On shore summer winds bring enormous quantities of rain, especially where they rise against mountain fronts.

The true monsoon regions merge with regions along the east coasts of lower middle latitudes in which the alternation of wind direction between summer and winter is statistical rather than permanent. In other words, the average wind direction of winter is north or northwest, both in southeastern United States and in southeastern China, because the polar outbursts come with great frequency at that season. They are occasionally interrupted, however, either by spells of still air between outbursts, or even by warm air masses of the oceanic whirls. In summer, on the other hand, the oceanic whirl is dominant, and winds are mostly from the south and southeast; but even in that season there are occasional interruptions as cold air masses push southward. Actually the monsoon of all of southeastern United States, including that of the margins of the Gulf of Mexico, is an average condition rather than an uninterrupted condition, both in summer and in winter. The monsoon of India, however, protected as it is by high mountains to the north, is almost never interrupted. The two kinds of monsoon in Asia are merged somewhere in the southern part of China.

As a result of all these conditions, the rainfall in the middle latitudes is especially heavy along the whole east coast, and along the west coast poleward of 40°. The continental interiors are dry; but poleward of about 55° in the Northern Hemisphere temperatures average low enough, even in summer, so that the small amount of rain which does fall is highly effective.

The Vegetation Types and Their Distribution. The mid-latitude mixed forests are composed of a number of different forest associations, some including both broadleaf trees and conifers and some composed

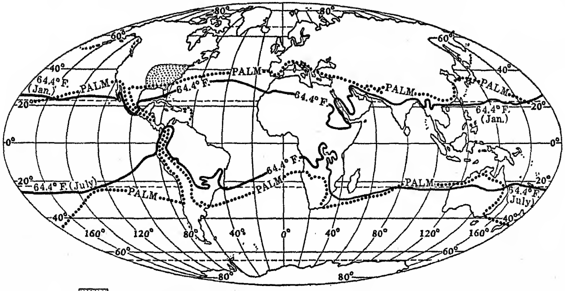


FIG. 55. *The limits of the palm, the isotherm of 64.4° for the coldest month, and the limits of the black oak in the United States*

wholly of one or the other. Along the continental east coasts, the forests of Group IV are distinguished from those of Group II because of the predominance of species which can endure cold weather in winter. The palm, for example, is a characteristic low-latitude tree, and it does not flourish poleward of 30°, although stunted palms actually are growing poleward of this. The poleward limit of the palm is shown on Fig. 55, together with the coldest-month isotherm of 64.4°, which is commonly used to distinguish climates with mild winters from those with no winters. The same figure shows the distribution in the United States of the black oak (*Quercus velutina*), which is a tree distinctly adapted to mid-latitude conditions. The boundary between the low-latitude and middle-latitude forest types is obviously a zone of transition, and the actual line drawn on the plates (Plates 10–20) is an arbitrary one.

The boundary between broadleaf forests and conifers is even less distinct. Conifers are found far equatorward in the winterless regions of the tropics. The characteristic vegetation of large parts of Florida, Cuba, and the Bahamas is a mixture of pine and palmetto. Throughout the regions of Group IV, on both sides of the continents, there are "islands" or enclaves of pure coniferous forests in the midst of the predominant broadleaf forests. Usually these islands are located on areas

of exceptionally poor soil. Pine occurs in pure stands, for example, on the sandy coastal-plain soils of southeastern United States. It is found also on the sandy glacial soils of the Lake States and of Europe southeast of the Baltic Sea. On the highlands of southeastern United States, and in a similar position in South Brazil, the original forest was composed of a mixture of pine and broadleaf trees. There are also pine forests on the very rainy mountain slopes of the west coast of the Northern Hemisphere, but only broadleaf trees in a similar position in South Chile. The greater part of the regions of this group, however, were covered originally by various associations of broadleaf trees.

On the poleward side in the Northern Hemisphere, where Group IV borders the forests of Group VI, there is a relatively sharp line of demarcation. The forests of the northern lands having severe winters and short summers (Group VI) are made up of pure stands of conifers, chiefly spruce and fir.

On the interior side of Group IV, the mid-latitude mixed forests are bordered by grasslands. Here, as in the case of the tropical forests, the boundary is not always sharp, although it may be sharpened in some regions because of frequent grass fires which keep back the spread of young trees. Long fingers of galeria forest extend along the river valleys far out into the grassy regions. The broadleaf forests on the grassland margins are in many cases stunted and scrubby.

SURFACE FEATURES

A discussion of these generalized patterns of forest distribution gives us a basic understanding of the factors or controls which produce the major lineaments of the face of the earth. But it is also true that each continent, each area of mid-latitude mixed forest, can be identified because of its own unique arrangement of physical features. The particular patterns developed on each continent and in each major natural region result from the configuration of the surface and the trend of the coasts. No generalized pattern of surface features can be shown on the generalized continent because, as we pointed out in the introduction to this book, the relief features of the earth are not symmetrically arranged with reference to the equator and the poles.

The regions of Group IV, then, are all different in the arrangement of their physical features. Of all these regions, however, the ones which are located in Europe are the most intricate in pattern (Plate 15 and Fig. 68). With a much indented coast line, and with many mountain ranges and enclosed basin plains or uplands, this continent is composed of a large number of distinct natural regions more or less isolated from one another. The largest area of low relief is in the east, extending from the Black Sea to the Arctic. Only in its central part is it included in Group IV. Toward the west this plain narrows down like a funnel, constricted on the north by the Baltic Sea and on the south by the mountains and uplands of central Europe. The end of the funnel is on the shore of the North Sea. Here the natural lines of circulation come to a sharp focus; for not only is this the apex of the plain just mentioned, but also it is easily reached from the south through a series of basins and river valleys. Just south of the Plain of Flanders lies the Paris Basin, united by low passes to the Aquitaine Basin and to the Mediterranean through the Saône-Rhône Valley. The Rhine, also, leads to the North Sea. Even in the British Isles the largest lowland area, on which London is situated, faces the North Sea. In this portion of Europe, therefore, is one of the world's greatest foci of natural lines of travel, as guided by the configuration of the surface.

In contrast to Europe, eastern North America is built on a pattern of relative simplicity (Plate 9 and Fig. 82). Its plains are extensive and continuous instead of being broken into numerous isolated units. The various parts of the Appalachian-Ozark system of hilly uplands and low mountains, extending southwestward from New England, are arranged in simple linear fashion, separating the coastal plains of the east and south from the central plains of the interior. The Mississippi Valley, south of the mouth of the Ohio, is one of the world's major river floodplains (Fig. 87). Aside from the several natural foci of routes of travel in the interior of eastern North America, the natural outlets across the barrier of highlands are three in number. Perhaps the most obvious route from the interior plains is down the Mississippi to the Gulf of Mexico. Another natural outlet is provided by the St. Lawrence. For historical reasons, however, a third natural highway has been of greater importance than either of the other two: the


Ewing Galloway, N. Y.

FIG. 56. *A hilly upland in the Appalachian region*

Hudson-Mohawk route, by which an easy passage of the Appalachian system is made (with a climb of only four hundred and forty-five feet). This pass contributes an important part of the focus of natural lines of travel on the site of New York City.

Very different from either Europe or eastern North America are the Asiatic borderlands (Plate 17 and Fig. 61). Here the areas of lowland are relatively small, being restricted by many ranges of hills and mountains to the alluvial valleys of the great rivers. Furthermore, the regions of Group IV are limited to the continental margins by the lofty mountains and desert plateaus of the interior. In China the two mighty rivers, the Yangtze Kiang and the Hwang Ho,[1] have formed the largest areas of lowland, south and north of the Shantung peninsula. Loess, carried by the wind from the deserts of the interior, has been added to the river alluvium to build the Hwang Plain. Smaller valleys, such as the Si Plain of South China, the Chengtu Plain of the interior, or the river plains of southern Manchuria, are found in scattered positions, isolated by the highlands. The southern side of Korea consists of narrow valley lowlands separated by transverse belts of hills descending from the

[1]In the language of North China the word *ho* means "river"; in the language of South China *kiang* means "river." It is incorrect to speak of the "Hwang Ho River."

Three Lions

FIG. 57. *Mt. Asama in the Japanese Alps*

backbone of high mountains along the east coast. The islands off the coast of Asia, such as western Formosa (Taiwan in Japanese), and most of Japan are included in Group IV. Japan is crossed by a zone of high mountains, the Japanese Alps, which cut across Honshu from the west coast to the southeast coast between Tokyo and Nagoya (Fig. 135). The rest of Japan is composed of low mountains and ranges of hills, enclosing small interior basins, and with numerous narrow strips of coastal plain or delta plain.

The other parts of the world where regions of Group IV occur are all much smaller. In all of them the lowlands are closely hemmed in by mountains or hilly uplands. In western North America most of the land bordering the Pacific is mountainous (Plate 9). A long, narrow lowland, large enough to be distinguished from the bordering mountains, extends from Eugene, Oregon, to Puget Sound. In Oregon, south

of Portland, it is known as the Willamette Valley; in Washington it is called the Puget Sound Lowland. The lowland crosses the border into Canada, where it provides the site for the port of Vancouver in British Columbia. To the north, however, the steep mountain slopes descend directly to the sea, leaving only a few narrow delta plains too small to appear on the maps. In addition to providing for the port of Vancouver, Puget Sound offers fine protected harbors for Seattle and Tacoma.

In the Southern Hemisphere the surface features of the regions of Group IV, like the climates and the types of natural vegetation, show a close similarity to those of western North America. The Central Valley, already described in mediterranean Middle Chile, extends southward, like the Puget Sound Lowland, to the beginning of the embayed section at Puerto Montt. In South Brazil the mid-latitude mixed forest region is found in the states of Paraná, Santa Catarina, and Rio Grande do Sul, and in the eastern part of Paraguay (Plate 11). This whole region consists of hilly upland and plateau, which faces toward the Atlantic with a steep escarpment some 3000 feet in elevation. On the border of Brazil and Paraguay the upland is cut by the deep canyon of the Paraná River, and tributaries to the Paraná which rise near the crest of the escarpment flow westward in valleys which become deeper and deeper. The Iguassú River descends over great falls into the deep valley of the Paraná. In South Africa there is a small coastal strip which belongs in the regions of Group IV (Plate 13 and Fig. 12). It lies at the base of the escarpment capped by the Drakensbergen and extends from Port Elizabeth to and somewhat beyond Durban. Southeastern Australia is composed of small, isolated coastal lowlands, backed by hills and low mountains,—not unlike the Appalachians in degree of relief (Plate 19 and Fig. 50). Isolated plains are occupied by Brisbane, Sydney, Melbourne, and Hobart. In New Zealand, too, the lowlands are small and isolated, backed by dissected plateaus and rugged mountains.

DRAINAGE AND SOILS

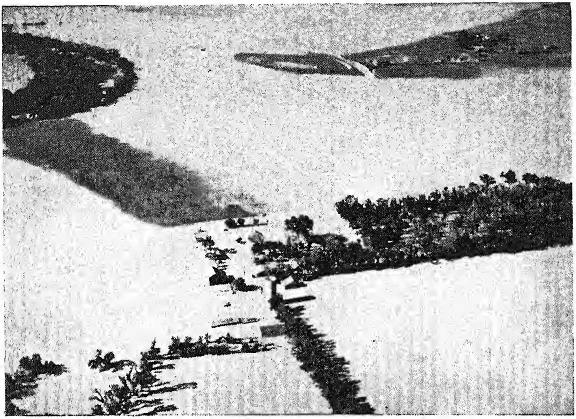
Most of these regions of Group IV are well-watered, but droughts occur as a result of variations of rainfall, just as in the tropical forest lands. That these droughts result in famines, especially in the densely

crowded agricultural lands of Asia, is a measure of the pressure of the population on the limits of subsistence rather than of the severity of the droughts. Similarly, the problem of providing a good water supply for the modern industrial and commercial great cities is a serious one and may even limit the size of these cities as it does in the dry lands. But compared with other parts of the world, the lands in this group have an abundant water supply.

Floods are perhaps more of a menace than droughts. In the monsoon lands every summer is a period of high water; but every few years more rain falls than usual, and the result is a disastrous flood in the lower courses of the streams. In the other parts of the group, floods occur during periods of excessive rainfall, especially if the rains come when the ground is frozen so that the water cannot sink into the soil. Spring floods associated with the melting of snow are common in the colder northern portions. The rivers are usually able to take care of the floodwaters, provided the tributaries do not all rise at once. The Mississippi floods of 1927, for example, were caused by the coincidence of several flood crests on the tributary streams (Fig. 58).

The removal of forests from the headwaters of tributary streams is an important cause of floods. As in the tropics, the runoff is much increased by the clearing of the land; and in the hilly areas of the middle latitudes, where snow may accumulate to considerable depth in a winter storm, the lack of a forest cover permits rapid melting to take place. The result is that the deforested slopes no longer act as reservoirs to hold back the water and maintain a more even flow, and therefore serious floods alternate with protracted periods of low water. An outstanding example of this is found in China. For more than four thousand years floods and droughts have punctuated its history as a result of the almost complete removal of the forest cover. Similar disasters have accompanied the removal of headwater forests in other parts of the world.

Soils. Many of the same processes of soil development which operate in the tropical forest lands are active also in the middle latitudes, but with certain significant differences. Leaching and eluviation take place wherever rain water is percolating through a soil to the ground-water



Soil Conservation Service, Photo by Slack

FIG. 58. *Farmstead and bottom land inundated by flood waters from a Kansas river*

table. But all chemical processes in the middle latitudes go on more slowly than in the low latitudes, owing to the lower temperatures and less extreme humidity. Humus accumulation, too, is possible in the middle latitudes; for the slower decay of organic litter on the forest floor results in the collection of a black mold, which, mixed with the soil layers, imparts a brownish color.

Three mature soil types are recognized in the regions of Group IV. The red and yellow colored soils of Group II extend poleward into the warmer parts of the mixed forest lands, and are known here as *yellow forest soils* (Fig. 59, *C*). Farther poleward, however, humus accumulation is sufficiently rapid so that the soil color is darkened. With the aid of earthworms the organic matter is mixed with the upper soil layers to form the *brown forest soils* (Fig. 59, *B*). On the northern borders of Group IV and extending into Group VI lie the *podsols.* In the profiles of the podsol the absence of earthworms is indicated by the concentration of the humus at the surface and the light, ashy color of the soil

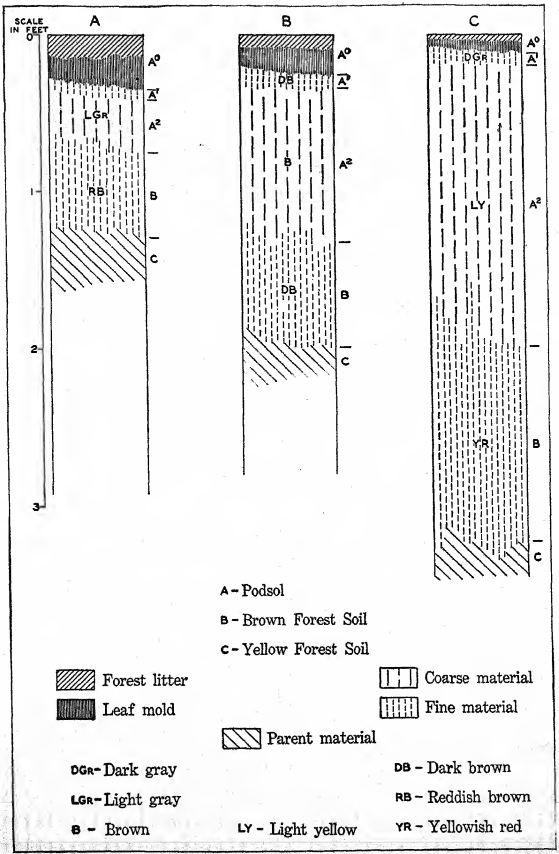


FIG. 59. *Generalized mature soil profiles developed under forests.* (After Jenny)

below (Fig. 59, *A*). The depth of these profiles decreases as the length of the frozen period of winter increases. None of these soils may be described as fertile.

Mature soils, however, with their distinct horizons, develop only on flattish surfaces where the regolith has remained undisturbed for a long period of time. Of much greater fertility are the immature soils, which have not suffered leaching and eluviation, although where these occur in hilly country the steepness of the slopes may make their agricultural use difficult. As elsewhere in the world, the alluvial deposits of river floodplains provide the most fertile lands.

The Occupance

These are the lands inhabited by nearly two fifths of the world's population. While the group as a whole, from the point of view of its physical make-up, is less homogeneous than Group III and resembles the tropical forest lands in variety of subdivisions, nevertheless the several parts are united by four common characteristics: (1) a forest cover, mostly composed of broadleaf deciduous trees but with a considerable mixture of conifers; (2) a climate with abundant rains, at least during the growing season, and with a seasonal rhythm imposed by distinct but not very severe winters; (3) soil types which, in undisturbed places, reflect the peculiarities of the climatic and vegetation conditions of the group; and (4) surface features which are not mountainous. Within the group different natural regions may be defined by the arrangement of the plains, plateaus, and hilly uplands, and by the various forest associations.

As in the tropical forest lands, the greatest contrasts between different parts of the group are not those resulting from the minor distinctions and variations of the natural setting, but, rather, those resulting from the occupance by people of very different cultural backgrounds. In spite of certain differences in the climatic regimes of southeastern China and southeastern United States, for instance, the great contrast which exists today between these parts of the world is more a matter of the culture of the inhabitants than of the nature of the habitat. How very different might have been the occupance of the North American

Three Lions

FIG. 60. *Working with machine-like motion these Oriental women transplant rice shoots*

Coastal Plain or the floodplain of the Mississippi if these areas had been settled by Orientals organizing their economy around the subsistence crop of rice and carrying on the necessary labor chiefly by the use of human muscles aided by few domestic animals and only the simplest tools! One of the essential characteristics of Occidental culture is the control of inanimate power. The large-scale development of trade in staple commodities which the modern use of power makes possible results in a utilization of the resources provided by the physical earth in a manner very different from that which has characterized any previous civilization. Although few cultures have failed to carry on some trade, no culture previous to the Occidental has been able to develop to such a high degree the continuous exchange of products between distant parts of the world. The result is a distribution of people in the Occidental lands which is quite different not only from the distribution of the earlier and more primitive inhabitants, but also from that of the present Oriental peoples in a similar habitat. In a very real sense the

human culture sets more rigid limits to the area a people can inhabit than does the physical make-up of the land (Fig. 60).

The land generally sets up opportunities or obstacles for human settlement; but to the progress of that settlement or its outcome the natural environment remains indifferent—as indifferent as sunlight and soil to the growth of a plant. Not that any one system of connections between the occupance and the land is enforced by the physical setting: on the contrary, if only one system of occupance is enforced, it is because of the primitive nature of the human culture—its lack of adaptability. The more advanced and complex cultures have a great variety of ways of making use of the land; but whatever mode of occupance is practiced, it must form some kind of a harmonious connection with the physical earth. The stimulus and the plan for the transformation of the natural scene into one that is genially civilized are inherent in the human culture; the land provides the fundamental materials and patterns of arrangement (Fig. 61).

OCCUPANCE BY ORIENTAL CULTURE

The agricultural occupance of all forest lands must start with the clearing of the vegetation cover.[1] This may be a haphazard and temporary effort, as in the case of a primitive people practicing migratory agriculture; or it may be a more lasting accomplishment, resulting in the permanent transformation of the original landscape. Both extremes have already been illustrated by examples in the tropical forest lands. The early stages of occupance, during which almost all traces of the original natural vegetation were obliterated, were passed through in China thousands of years ago.

The present pattern of occupance in China is the product of many centuries during which the way of living has changed but little. Until

[1]It seems probable that the Plain of North China as far as the Hwang Ho was a grassland at the time of the arrival of the earliest inhabitants. The Yangtze Valley was probably forested. See C. W. Bishop, "The Neolithic Age in Northern China," *Antiquity*, Vol. 7 (1933), pp. 389–404, reference on page 389; and idem, "The Rise of Civilization in China with Reference to its Geographical Aspects," *Geographical Review*, Vol. 22 (1932), pp. 617–631, and previous articles by the same author to which reference is made in footnotes in these papers.

Fig. 61. *Eastern China*

recently this pattern was crystallized in close adjustment to the qualities of the land—a true climax of occupance in terms of the Oriental culture. The chief features of this ancient pattern still persist; but during the last century or so contacts with Europeans have brought about profound changes in the ways of living, and a transformation of occupance is impending.

General Population Distribution. The outstanding fact regarding the present distribution of people in China is their concentration in the few areas suitable for Oriental agriculture. There are six chief areas of

very dense population (Fig. 62). The first of these is the central part of the Hwang Plain, where the alluvial and loessial lowlands of the Hwang Ho and its tributary, the Wei Ho, the cradle of Chinese culture, still support more than 1000 people per square mile. The second area of concentration is the delta of the Yangtze Kiang. In the vicinity of Shanghai the rural population is said to exceed 2000 to the square mile on the fertile delta soils. The third area occupies the delta of the Si Kiang, centering on Canton, and here, although the area is smaller, densities similar to those around Shanghai are believed to exist. Thus in all these areas the population is at least 1000 people per square mile (Plate 5).

The Szechwan Basin stands out conspicuously on the population map. In the basin as a whole the density runs as high as 400 or 500 per square mile, but in the Chengtu Plain, near the western margin of the basin, the density is probably about 1700. The fifth heavily populated area is along the coast between the cities of Canton and Shanghai, where a series of lesser delta plains forms a string of miniatures of the much larger Yangtze or Si deltas. Finally, the sixth area is the central basin of the Yangtze, where the convergence of numerous valleys has developed a distinct focus of communications on the ancient commercial center of Hankow.

These six regions of dense population comprise only a very small portion of the previously forested sections of China. The remainder of the area included in Group IV is composed of uplands with only narrow valley lowlands or mountain-rimmed basins. Here the people are also concentrated in the valleys, with densities similar to those in the centers just listed; the upland areas support only a very scanty population.

A Closer View of Population Distribution. In topographic detail, as well as in the broader aspects, the population pattern is closely adjusted to the land. Considering, for example, the densely populated Hwang Plain, we find parts of the area with extraordinary concentrations of people, separated by strips of territory almost untenanted. The soil of the great alluvial plain is not of uniform texture; in some places it is composed of sands or gravels deposited by the swifter currents of

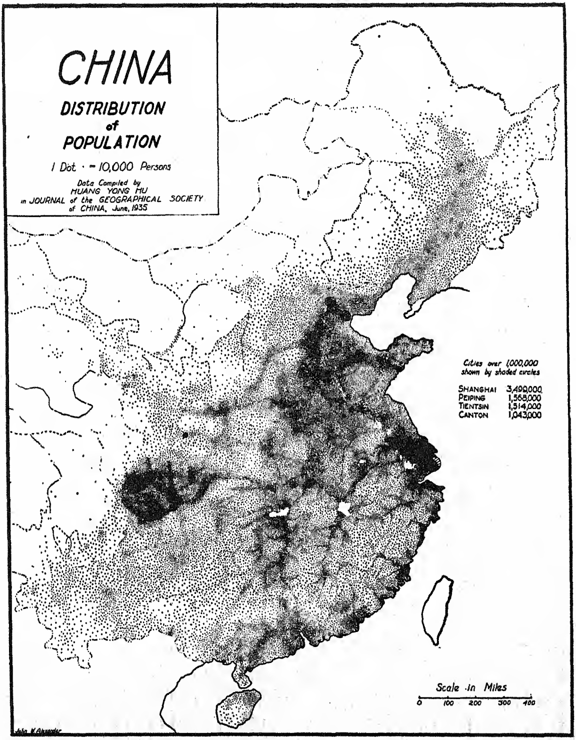


FIG. 62. *The population of China.* (Prepared by John W. Alexander, reproduced with the permission of the Annals of the Association of American Geographers)

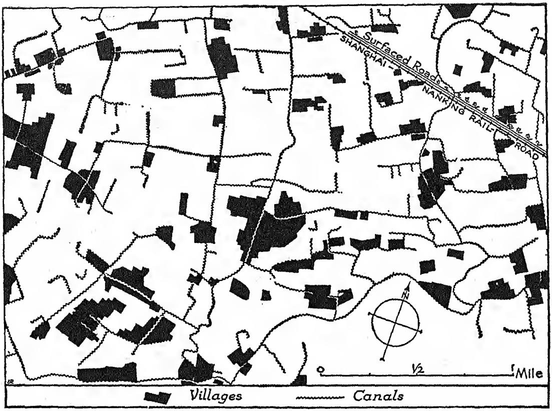


FIG. 63. *Topographic detail of the Yangtze Delta near Shanghai.* The railroad, built in 1909, is an Occidental feature superimposed on the ancient settlement forms of the Oriental culture. The space outside the villages is almost exclusively devoted to rice. (From the "Plan of Shanghai," Shanghai, 1928)

the stream, in other places it is poorly drained and marshy, and in still other places it is composed of fine-textured silts and loams which are ideal for intensive crop cultivation. The details of population distribution closely reflect these underlying qualities of the land; for the sandy or marshy tracts remain quite uninhabited, while the more favorable lands are so used that no small corner of ground is suffered to remain idle, except land that is used for the numerous cemeteries.

Only a very small proportion of the people live in cities. Urban life and the practice of the so-called urban functions are not entirely lacking in the Orient, but they have not been developed on anything like the Occidental scale. Not more than 6 or 7 per cent of the inhabitants live in cities of over 100,000, and only 12 per cent in cities of over 10,000. About 75 per cent of the Chinese population is grouped in small village agglomerations or disseminated on individual farms (Fig. 63). Nor do these figures tell the whole story, for many of the people who

live in the neighborhoods of the great cities of China and are included in the category of city population are in reality farmers. Compared with cities of the Western world, the typical Oriental city is essentially amorphous; that is, its commercial and residential areas are not separated except where the influence of the Occidentals is reflected in the development of a commercial core. Most of the population is rural. Furthermore, the traditional Chinese reverence for ancestors keeps each family closely attached to the land.

Oriental Agriculture. The nature of the agriculture has been the decisive factor in the establishment of these patterns of occupance. Oriental farming is based on the power of human muscles, supported in part by the power of buffaloes and horses. Though the Chinese farmer applies from two to four times as much power to an acre of land as does a farmer in the United States, he limits his work to a relatively small area. Excluding Manchuria, Outer Mongolia, Sinkiang, and Farther Tibet, the total area under cultivation in the rest of China (the most densely populated part) is only 27 per cent. For China as a whole the cultivated area is only about 10 per cent. The average per capita amount of farm land in China is about half an acre. The average size of the farms, too, is small—only a little over three acres for all agricultural China. This concentration of effort on small areas of good land, to the almost total neglect of the poorer land, is the result of the inherited traditions of agriculture. Because of the dependence for power on men and domestic animals, large acreages per farm, which alone would make possible the support of an agricultural population on poorer lands, cannot be successfully maintained. Since a man with a spade and a hoe cannot take care of much over an acre in the time required by the passage of the seasons, he must concentrate his work on only the better places if he is to support his family. To attempt the cultivation of hilly or sandy lands, which might bring sufficient yields if large areas were cultivated by machinery, would mean starvation for the Chinese farmer. Unable to increase the acreage, the Oriental must increase the yield per acre by every available means: by irrigation, by the most painstaking care of the soil and of the growing crop, and by the use of large amounts of fertilizer. Obviously any interruption of the

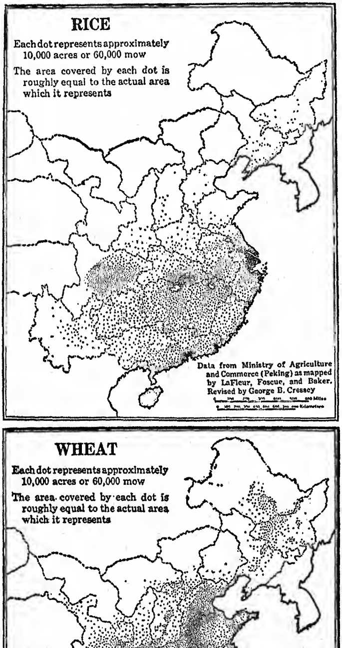


FIG. 64. *Rice and wheat in China*[1]

farm activities, such as might result from floods, from droughts, or from warfare, brings large numbers of the inhabitants to the verge of starvation.

Crop Combinations. The two dominant food crops of China are rice and wheat. Rice is the basic support of the population as far north as the 30-inch rainfall line (Fig. 64). The climatic conditions of hot summers with heavy rainfall are ideally suited to rice; but on the Hwang Plain the rainfall is not sufficient for this moisture-loving cereal. Compared with rice, wheat is a dry-land crop and does poorly in areas of heavy summer rains. Wheat, therefore, is of little importance south of the Yangtze Valley.

Three chief agricultural areas can be identified. In the south rice is the one staple crop. In the north spring wheat and millet are the crops which sup-

[1]From George B. Cressey, *China's Geographic Foundations*, McGraw-Hill Book Company, Inc.

port the dense populations of North China. Between these two extremes, in the Yangtze Valley from the delta to the Szechwan Basin of the interior, rice and wheat are mixed, with rice as the summer crop and wheat grown on the dry paddies during the winter.

In addition to these staple crops certain other crops have been localized in various small areas. Silk and cotton are produced along the Yangtze Valley, especially in the delta region. Tea is of importance in the hilly country back from the coast between Shanghai and Canton. In the south sugar cane is added to rice as a minor crop.

Contact with Western Culture. A number of very significant changes have taken place in China within a century as a result of contact with people from the Western world. Not the least is the change in the character of Chinese trade as a result of Occidental influence, for trade in the Occidental sense is of a quite different order from that found in any other culture. The exchange of commodities was, of course, carried on in China previous to the arrival of the Europeans. As a matter of fact, there had long been an important trade between China and India, which was probably the means of introducing rice into China; and there was also in progress a considerable exchange of commodities with western Asia and the Mediterranean lands across the high, bleak steppes of the interior of the continent. Within China, too, the contrasts in production between the north and the south and between the east and the dry west stimulated a commercial development. This trade was carried on in part by small boats on the rivers and canals and along the coast, and in part by human porters. The convergence of the natural routes of river and land travel on certain focal places led to the growth of such important ancient market towns as Chengtu and Hankow (Fig. 61).

The arrival of the Westerners in large numbers during the nineteenth century imposed a very different pattern of trade. Instead of being drawn to interior market towns, trade has been drawn to the coastal ports. Here the European nations have either established a definite ownership of strategic places (such as Hong Kong) or have gained from the Chinese government the concession of certain districts in the port cities where the foreigners reside and manage their own

Charles Fenn from Three Lions

FIG. 65. *The porter and the river boat are important links in Chinese transportation*

affairs. The Occidentals have built railroads and established steamboat lines on the rivers (Fig. 73). With foreign capital industrial plants have been started, especially in the cluster of cities on the Yangtze delta surrounding Shanghai. The very dense population of this delta has been built up during the last century and is quite definitely related to the growth of this new urban center.

China is in turmoil. The ancient ways of living are breaking down in the face of importations from the Western world, not only of such material things as machines and factories but also of religious and political ideas. The old patterns of distribution must dissolve as the new ways of living are absorbed or enforced. So close is the traditional attachment of the Chinese peasant to his land that it seems scarcely possible to move him. Yet efforts to introduce machinery and undertake the cultivation of larger farms on the poorer lands can only result

in the complete disorganization of the present agricultural economy. Perhaps the hordes of families who will be unable longer to gain a living in the traditional way may find a place in the industries or in the coal and iron mines. China is fortunate in possessing potentially important coal reserves; in fact, China stands fourth among the countries of the world in its supply of coal. Coal occurs in almost every province, but the most important fields are in the highlands west of the Hwang Plain. Before World War II coal mining had been started in the more accessible places, chiefly southeast of Mukden and north of Tientsin (Fig. 193). The largest fields remained scarcely touched. Minerals such as tin, antimony, tungsten, and others occur in the hilly country south of the Yangtze, and there is some iron in the north. With these minerals, with new agricultural products, and with a large-scale development of coal mining, China could support manufacturing industries; but to develop an urban industrial economy would inevitably lead to the transformation of the ancient and crystallized patterns of occupance into patterns radically different. Such transformations cannot be other than painful.

China's Population Problem. The most serious aspect of this whole process of change is the increasing pressure of population on the resources of the land. China has one of the highest birth rates in the world, averaging somewhere between 45 and 50 per 1000. But this birth rate has been almost balanced over the centuries by a very high death rate. Deaths which result from famines, from epidemics, or from the ravages of war have repeatedly swept over whole regions of China. Both floods and droughts, in a land so intensively used, have meant starvation for millions; in a land where sanitary measures are completely lacking, epidemics take a heavy toll in crowded communities. The result is that China's population has increased only very slowly over many centuries.

Now two importations from the Occidental world threaten this balance of births and deaths. The increased availability of medical service alone must decrease the death rate. And as rapidly as industrial establishments are built in the cities and more Chinese find better incomes and larger purchasing power as a result of industrial wages, this,

too, will have an important effect on the rate of death. More and more children will survive to reproductive age. Yet all previous experience tells us that the birth rate will not similarly be affected.

The possible increase of China's population during the next two or three decades staggers the imagination. If the net rate of growth is estimated to be approximately the same as that of India, the population of China in 1980 will have passed 700,000,000. What does this mean for the Chinese and what does it mean for the rest of the world? Even the most enthusiastic student of China's resources agrees that neither agriculture nor industry can be adjusted in that period of time to provide for such numbers. If China adopts sanitary measures without industry, the country cannot fail to remain economically weak, with a great majority of its people living on the verge of starvation. If China builds industrial plants and gains economic strength, will its leaders be able to resist the nationalist and expansionist ideas that Japan, under similar circumstances, adopted from the Occident? As Dr. Warren S. Thompson writes: "From the standpoint both of the welfare of the Chinese people and of our own position in the future when China has a greatly increased population and enough industry to make her a formidable military power, help to China in modernizing her economy should be made contingent on the willingness of the Chinese leaders to show their people the need for voluntary control of population growth."[1]

Japan. Japan, however, rather than China, was the first Oriental country to develop a strong reaction to the Occidental world. Japan has often been compared with Great Britain, a comparison which is superficially suggested by the similarity of island location off the continental shores. But such comparisons should never be given too much emphasis, for it is a fact which we encounter again and again that each country and each region is unique and requires its own individual analysis and interpretation. In almost every respect, except island location, Japan differs from Great Britain.

The Japanese people are diverse in origin. The earliest inhabitants of the islands who have survived to the present time are the Ainus, a

[1]Warren S. Thompson, *Population and Peace in the Pacific*, Chicago, 1946, p. 216.

people of Caucasian origin, who came originally from the Asiatic mainland, and who have been driven from the more accessible parts of the islands to remote and less desirable places by the later invasions of Mongoloid peoples. The groups following the Ainus came from the Asiatic mainland by way of Korea, and from the southeast Pacific by way of Formosa and the string of small islands connecting southern Japan with Formosa. The racial and cultural heritage brought by the migrants from China and from the south are predominant in present-day Japan. The racial strains which originated in the south make up some 60 per cent of the modern Japanese; although many aspects of the Japanese way of life were carried from tropical regions of the East Indies, the contribution of China to the culture of Japan was fundamental. From all these racial and cultural mixtures, however, the Japanese have evolved a fairly uniform society which differs in important ways from other Oriental societies.

Of basic importance in understanding Japan is the fact that for 268 years, from the early seventeenth century to the late nineteenth century, the country remained in seclusion from the rest of the world. To protect their culture from the teachings of the Christian missionaries, the rulers of Japan maintained the strictest blockade against outside contacts. During the period of rapidly expanding empires following the Industrial Revolution in Europe Japan was inactive. European countries were establishing bases such as Hong Kong along the shores of China while the Japanese were engaged in unifying their own domestic way of life. Not until Commodore Perry in 1853 succeeded in forming personal contact with the Japanese ruler, and not until the Meiji Restoration in 1868 brought in a government with a new policy of participation in international affairs, was the career of modern Japan launched.

After 1868 the transformation of the Japanese way of living went on with unexpected rapidity. On a purely self-sufficient agricultural economy, based chiefly on rice, the Japanese superimposed an urban-industrial economy which was dependent both on imports of raw materials and exports of manufactured products. Japan lacks most of the industrial raw materials. To build a steel industry it was necessary to import iron ore or scrap iron, and to import coal suitable for metal-

lurgy. To build a cotton textile industry it was necessary to import cotton. But for industries of this sort Japan was able to develop a large potential supply of hydroelectric power. Before World War II, Japan was surpassed only by the United States and Canada in the production of hydroelectric power. Its chief industrial resource, however, was an abundance of cheap but efficient workers. Except for the cotton textile industry, the capital for the industrial development was furnished by government subsidy, largely from taxes on the silk producers.

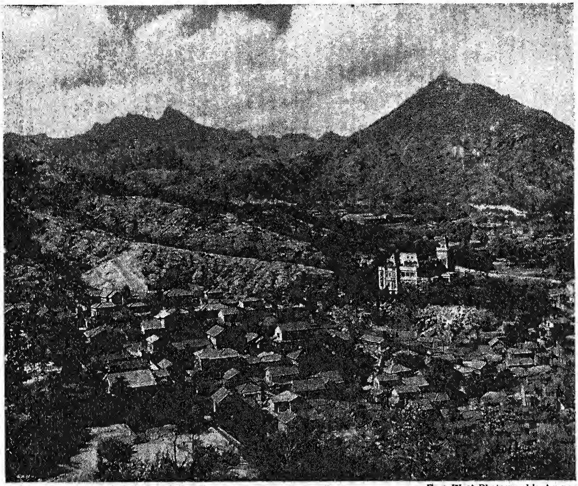
Industrialization profoundly altered the Japanese way of living. While Japan was isolated from the rest of the world the population remained nearly constant—a little below 30,000,000. This was about the number that could be supported by an inefficient feudal system of agriculture; population increase was limited by repeated famines and epidemics. After the Meiji Restoration, however, cities began to grow rapidly. Although the rural population has remained relatively constant, since 1872 the urban population has increased rapidly and at an accelerated rate. In 1920 about 12 per cent of the total population lived in large cities (over 100,000); in 1940, 29 per cent of the people were living in such cities. The major cities which grew so rapidly are located along the southeastern coast of Honshu and around the Inland Sea between Honshu and Shikoku. They include Tokyo, Osaka, Yokohama, Nagoya, and Kobe (Fig. 135). Kyoto is the only great Japanese city with an interior location.

The rate of population increase in Japan had decreased somewhat before World War II. Some students of demography suggest that this represents the beginning of a trend toward a static population similar to the trend already familiar in Occidental countries. Further analysis shows that a decline in the birth rate has, in fact, appeared in the cities, but that this decline is small (from 34.09 in 1930 to 31.69 in 1937); and the major factor in limiting population increase is still a high death rate. Japan's total population in 1946 was 76,000,000; it is estimated that by 1955 the number will have risen to 83,000,000. On an agricultural base which has changed little during the years of Japan's rise to world prominence, and with an industrial structure broken by war and restricted by the watchful control of the victors, such a large population will prove difficult to support.

Harold Lindner from A. Devaney, Inc., N. Y.

FIG. 66. *Looking over the city of Tokyo*

Japan, like certain Western countries, used a large and increasing population as a reason for territorial expansion. In a series of wars beginning in 1894 the Japanese extended their control over many parts of mainland Asia, including near-by Korea and Manchuria, and over strategically located islands in the south Pacific. During World War II the territory conquered by Japanese arms included the Netherlands Indies, Malaya, and the Philippines, as well as the most productive and densely populated parts of China. But territorial conquest in a world already occupied is no longer a solution to population pressure. Solutions can be found, but they lie in the direction of increased productivity of useful goods per person, not in the use of human and earth resources for purposes of destruction. Japan must renovate her agricultural techniques, and rebuild an industrial structure more closely in



East-West Photographic Agency

FIG. 67. *The city of Seoul, Korea, once dominated by Japan*

harmony with the facts of world geography. To attempt the development of a steel industry simply to give military strength is uneconomic; to utilize the advantages of the country for the low-cost production of manufactured goods is the only way out. This means that access to raw materials necessary for such industries cannot be denied, nor can markets be artificially closed to the kinds of things the Japanese can make advantageously. Otherwise the hopeless conditions of life in Japan may provide fertile ground for new schemes of aggression and conquest.

OCCIDENTAL OCCUPANCE

China and Japan are not the only parts of the world that face an uncertain future. The focus of confusion and conflict in the world today is the nuclear area of Occidental culture—the continent of

Europe. But the conflict is not confined to Europe, for in a world reduced in size by modern technology every remote inhabited place is intimately concerned with what happens in other inhabited places. We have suggested in the introduction to this book that from a broad point of view the basic cause of this world-wide confusion is the necessity for readjustment of man's relation to the land owing to the enormous increase in his technical capacity to produce.

The Occidental culture is sharply divided today into three parts. The changes accompanying the application of controlled inanimate power to production and transportation have led to the development of the industrial society—a society characterized by great urban concentrations, by enormous productive capacity, by huge volume of trade, and by many new economic, political, and social institutions. This new society had its beginnings in the countries bordering the North Sea in Europe. It spread only a little eastward into Europe, but across the ocean it developed rapidly in the United States, Canada, Australia, New Zealand, and South Africa; and at the present time it is making a start in Brazil, Argentina, and Mexico. Most of the Occidental world, however, is still occupied by a pre-industrial society—by people with a feudal pattern of living, with vast majorities of illiterate agriculturists and small minorities of people with political and economic power. And there is a large part of the Occidental world where the new soviet society has made its appearance.

The rise of the industrial society has been accompanied by a great increase in the population, for reasons similar to those we have just described for China. One of the characteristics of the industrial society, however, is the eventual decline of the birth rate and the appearance of a stationary or even declining population at a much higher level of density than existed before industrialization. But as the pre-industrial and soviet countries adopt the technical aspects of industry, they in turn are beginning the cycle of rapid population increase.

The industrial society has also adopted certain attitudes and objectives with respect to the world and its resources that set it off from the pre-industrial society. Self-sufficiency is by necessity abandoned because the locality can no longer provide enough of the materials of food, clothing, and shelter. Earth resources in sufficient quantity to feed the

great industrial plants must be gathered from the whole world, not from any one part of it. Self-sufficiency is given up for interdependence. Life becomes richer, more varied, and potentially more secure from the results of natural disasters; but in times of economic or military conflict, when the free flow of commerce is interrupted, the very existence of the industrial society is threatened. For this there is no solution except the wide acceptance of the concept of "one world."

EUROPE

All three of the present major divisions of the Occidental world had their origin in the mid-latitude mixed forest lands of Europe. In this area, today, are the largest concentrations of Occidental people (Plate 4). On a world map of population Europe stands out as one of the areas of greatest density. The key to the problems which beset all Occidental people and which are disturbing the ancient patterns of the Orient is to be found through an analysis of the relation of people to land in Europe.

The Background of Settlement in Europe. Europe is not really a continent at all, except in name. An examination of the globe shows that the great land mass of Eurasia is formed like an isosceles triangle, with its base at the east coast of Asia and its apex in western Europe. No barrier of any sort separates Europe from Asia; in the course of many centuries people have migrated back and forth from the great central heartland of Asia to the various peripheral areas, of which Europe is one.

There is an important difference, however, between the broader eastern part of Europe where it adjoins Asia, and the narrower, western part. West of a line drawn from Leningrad to Trieste most parts of the land are easily accessible to people with ships (Fig. 68). There are three reasons for this. In the first place, the land itself is tapering so that no part of the continental interior is far from the ocean. In addition, the coast line of this part of Europe is deeply indented and has many excellent harbors. And, most important, this part of Europe is crossed by a series of navigable rivers. The Seine-Saône-Rhône system

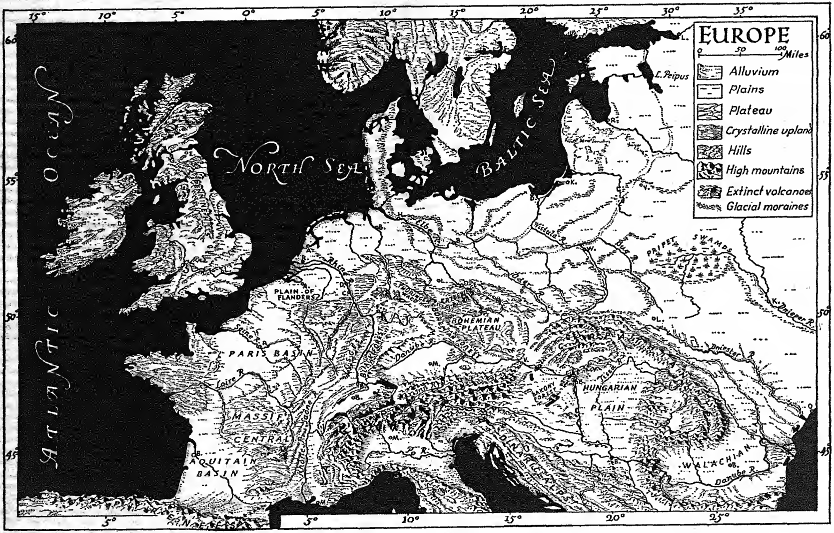


FIG. 68. *Europe*

provides a fine route of travel and communication which was of special significance to a people otherwise dependent on transportation overland by horse and wagon. From the Saône, the Gap of Belfort between the Vosges and the Jura gives access to the Rhine, which, in turn, is navigable to the North Sea. The Elbe and the Oder, together with other smaller rivers, connect the North Sea and the Baltic with the heart of western Europe. In contrast, eastern Europe is much less accessible for people with ships, except for the Danube, which leads to the Black Sea.

This difference was of importance to the people who settled in the forested regions north of the Alps. The difference in outlook between people close to the sea and people distant from the sea remains even today; and the conflict for power between maritime people and continental people has yet to be resolved.

The People of Europe. Europe was thinly populated north of the Alps when the Romans pushed their conquest across Gaul and into Britain. The Celtic tribes who came very early to the forests near the apex of the great Eurasian triangle were pushed on by later migrants. Today the parts of Europe which are predominantly Celtic are the westernmost islands and peninsulas (Fig. 69). About 2000 B.C. the Germanic tribes were in southern Scandinavia and on the plains between the Rhine and the Oder. Seeking better crop land where summers were warmer, they pushed southward into what is now France, and into the middle valley of the Rhine, and into the upper valley of the Danube. Wherever the forest was thin, or where heaths offered land which was entirely open, they established settlements and planted crops; but between the settlements were large areas of untouched forest, pictured in German mythology as the dwelling places of gods and demons. To the east were the land-minded Slavs, a pastoral people but recently come from the grassy steppes of the Eurasian interior. They established fixed villages wherever lands could be cleared for pasture. Many of these early Slavic villages are marked today by large cities, identified as Slavic in origin by the endings *-in* or *-zig* (such as Berlin or Leipzig).

The Romans brought language and many social and political ideas to western Europe. When Roman power collapsed, people in the area

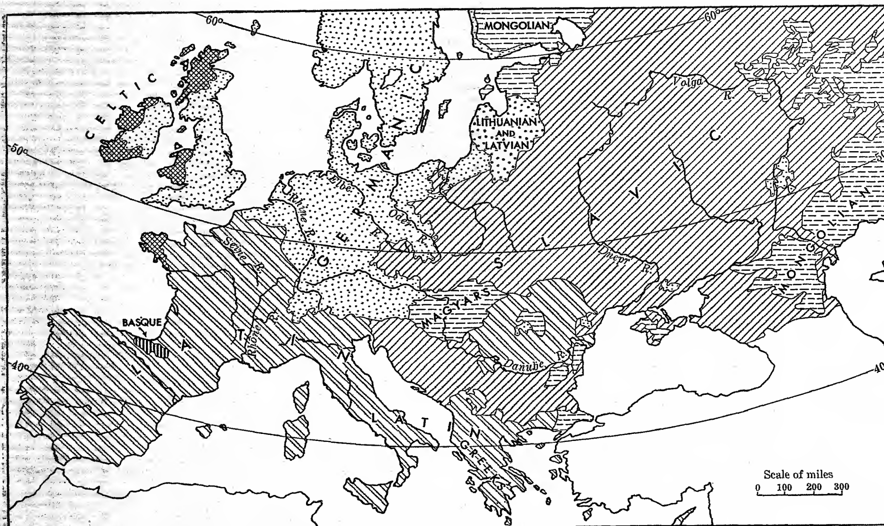


Fig. 69. *Ethnographic map of Europe.* (After Bartholomew)

west of the Rhine continued to speak a Latin language, but the Germanic language persisted east of the Rhine. English was enriched from both sources. The relation of people to the land, both among the Latin people and the Germanic people, was based on the feudal concepts of the Romans. Feudalism was the basic and widespread way of living in Europe before the rise of the industrial society, and to this day it characterizes the pre-industrial society wherever it is found.

Medieval Europe. Medieval Europe was still not densely populated. There were areas of concentrated settlement, but between them were large expanses of uncut virgin forest, mostly uninhabited. The land was divided into large domains ruled over by lords but occupied chiefly by an illiterate peasantry.

Essentially each community was a self-sufficient unit of settlement. To be sure, the lord of the land and the retainers who lived with him in his castle and the officers of the army that maintained his rule could make use of foods, articles of clothing, and luxuries brought at high cost from distant places. But the great majority of the people lived on what they produced from the immediate locality.

Under the traditional agricultural system the soils of Europe did not give large yields. The brown forest soils soon declined in productivity when used repeatedly for grain crops without the addition of fertilizers. To cope with this fact the "three-field system" of farming was used. Rye or wheat was planted in a field one year; the following year the same field was used for barley or oats; and in the third year the field was permitted to stand idle or in fallow. Animal manures were not used, even where there were cattle. Under this system the yields of wheat were only six to ten bushels to the acre, and few of the communities were safely beyond the danger of famine caused by local crop failure. The density of population was closely related to the quality of the soil for grain-farming.

The Emergence of the Industrial Society. The emergence of the industrial society and the appearance of modern Europe involved a number of basic changes in the attitudes, objectives, and technical abilities of the people, and with these changes came fundamental differences in

the distribution of people and the relation of settlement to the physical earth. The inhabitants of the island of Great Britain played an important role in these changes.

Why should such important cultural developments have appeared first in Britain? There is certainly no one simple answer to this question. It is true that Britain enjoys a stimulating climate, with frequent changes of weather and without great extremes of heat or cold, flood or drought. It is true also that the British people were made up of a variety of ethnic strains. The channel which separates the island from the mainland gave just enough protection from repeated invasion and conflict to permit early political unification and more attention to nonmilitary matters than the people of the mainland could afford. The British people turned to the sea, and their ships sought commercial connections in the most distant parts of the world. The homeland was mostly too rainy or swampy to make first-class agricultural land, yet the island was not lacking in products. Traders came very early to exploit the tin ores of Cornwall. In the medieval period wool was sent across the channel to Flanders, where skilled workers made it into clothing. Britain had long been accustomed to dealings with places across the water; and the traders and explorers who blazed the trails to distant places brought back new and stimulating ideas as well as exotic and useful products.

The fact is that the first attack on the traditional way of living of the Occidental world was delivered in Great Britain. The first people to challenge the political and economic power of the landlords over an illiterate peasantry were the British. The first country to become dependent on distant sources of food for the support of all the people was England, which has been dependent on imports of wheat since 1750. The first change in the traditional three-field system of farming was made in England. During the second quarter of the eighteenth century the British farmers adopted a system of crop rotation. A field was used one year for wheat, another year for a cultivated forage crop, and a third year for hay. With the use of more fields for feed crops rather than for human food directly, the acreage in wheat dropped; but the yield per acre rose to between ten and twenty bushels to the acre. This was accomplished through the use of animal manures. The

animals greatly enriched the diet of the British, and at a cost low enough so that meat was available not only for the very wealthy but also for a large part of the population. More recently the use of chemical fertilizers has raised the wheat yields of Europe to thirty or forty bushels to the acre.

The Industrial Revolution also began in Great Britain. The first steam engine was patented by James Watt in 1769. The first iron bridge was built in 1779 across the Severn at Coalbrookdale in western England near the border of Wales. The first application of steam to the manufacture of cotton textiles was made in 1785 at Manchester in England. The first steam railroad in the world was opened in 1825 between Stockton and Darlington in the northeast of England.

Changing Patterns of Occupance. Within a relatively short period of time the significance of the physical earth with respect to the distribution of people and the patterns of settlement began to change fundamentally. Among the many changes in the relation of people to land which have appeared, and which are still in the process of appearing, we shall describe three specifically: the changes in the factors leading to the location and size of cities; the changes in the factors which combine to fix the routes of travel and transportation; and the changes in the significance of barriers to circulation.

The Location and Size of Cities. The new technology for the first time made it economically desirable and physically possible for large numbers of people to live together in cities. Before the era of railroads and steamships, food could not be brought to any one place in sufficient quantities to support millions of specialized nonfood-producing urban people. Nevertheless, small market towns made their appearance at places where people found it easy to come together from the surrounding country or to meet the ships that came from distant regions. Markets were not uncommonly located at cathedral towns where people came for religious purposes but stayed to trade. Market towns were usually found at the following places: where there were firm shores close to a protected anchorage for ships; at the heads of navigation on the rivers; at important river crossings; at the junctions of important

Philip Gendreau, N. Y.

FIG. 70. *Tiny villages nestle in the narrow valleys of the Alps*

navigable rivers or where important tributary valleys joined the main valley; at either end of mountain passes or in the gaps between hilly or mountainous regions. Wherever the physical conditions made necessary a change in the means of transportation or the size of the load that could be moved in one carrier, to such places people came to trade and small towns were established there (Fig. 70).

When the era of vastly increased commercial activity began, the pattern of circulation previously established was, in most cases, maintained. The small market towns grew into great commercial cities. In every country, however, there was a tendency toward the selection of one city for the major focus of trade and finance. In one center people could find the greatest variety of goods, the rarest articles, and the greatest development of the institutions which facilitate trade. To this one center came the most able people because here were the greatest

economic opportunities. As the supremacy of this one city became more and more apparent, not only traders and business people were attracted to it but also artists, musicians, writers, and people of wealth who wished only to enjoy the social life. The result was that one city in each country grew out of all proportion to the other cities. This is what Mark Jefferson calls "the law of the primate city."[1] In eighteen of the larger countries of the world the chief city is more than three times the size of the second city; and in twenty-eight countries the chief city is more than twice the size of the second city.

In addition to commerce, another factor became important in the location of large cities. This was manufacturing industry. To be sure, there had been manufacturing cities before the Industrial Revolution, but none on the scale of the modern era. Industrial cities in the pre-industrial society were generally built to serve a small market and were protected not so much by tariffs as by high costs of transportation. With the application of steam power to manufacturing, the presence of accessible coal for the first time in history became a factor in the location of large urban concentrations. Cheap transportation also made possible the location of manufacturing centers in places which earlier could not have supported such a large-scale economy because of the lack of a large enough market close by.

Large industrial concentrations have now been developed at or near the sources of good coal. First came the iron and steel industry. Coal is the raw material used in the largest volume in most regions of steel-making; for this reason it is usually less costly to operate a large-scale steel industry near the coal fields than near the sources of any of the other raw materials that are used. Directly or indirectly related to coal are many other kinds of manufacturing industries utilizing by-products or semimanufactured products. The great industrial concentrations of the present day include many different kinds of manufacturing, all in one way or another enjoying an advantage from location close to coal.

The Ruhr. The greatest industrial concentration in Europe and one of the few great concentrations of productive capacity in the world is

[1]Mark Jefferson, "The Law of the Primate City," *Geographical Review*, Vol. 29 (1939), pp. 226–232.

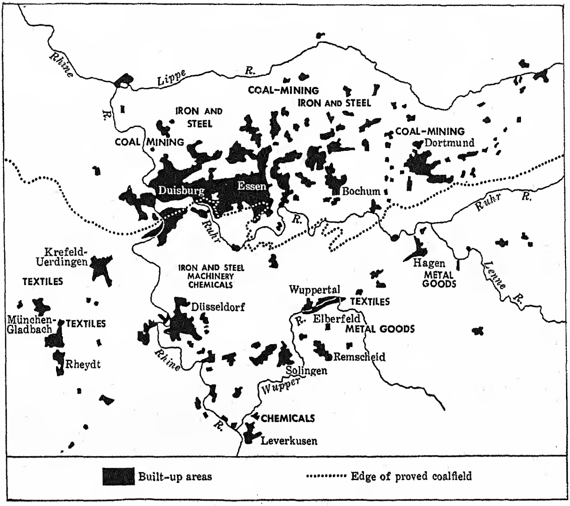


Fig. 71. *Urban development in the Ruhr District.* (After Chauncy D. Harris)

in the Ruhr—located on the east side of the Rhine northeast of Cologne (Köln). Ruhr coal made up 90 per cent of the bituminous coal of prewar Germany and represents about half of all the coal in Europe outside the Soviet Union. Coal has been mined in the Ruhr since the thirteenth century, but because of the cost of transportation most of it was formerly used at no great distance. The first use of coal to make coke, which, in turn, was used in making iron and steel, was in 1850. The building of the great industrial complex in this region was largely accomplished between 1850 and 1913. More coal was taken out of the ground in the Ruhr between 1920 and 1940 than in all the hundreds of years since mining was started in the area (Fig. 71).

Before World War II a great variety of industries and a great concentration of urban people occupied the Ruhr. In addition to coal

mining and the manufacture of pig iron and steel, there were industries making all kinds of products from steel; there were chemical and dye industries using by-products such as coal tar and its numerous components; there were textile and pharmaceutical industries based on the same materials. The Ruhr had become the productive heart of Europe, for it supplied a large proportion of the basic material to be manufactured elsewhere as well as many of the finished manufactures used throughout Europe. Of the coal mined before World War II, some 48.5 million tons a year were used in the manufacturing industries of the Ruhr itself; 39.6 million tons went to other parts of Germany; and 39.6 million tons were exported to the Netherlands, Belgium, France, Luxembourg, Italy, Switzerland, the Scandinavian countries, the Balkans, and oversea to Spain and other places. A very considerable part of the productive capacity of Europe was based on Ruhr coal.[1] The great concentration of people in this area (Plate 4) includes only a small proportion of the total people of Europe and outside of Europe whose way of living is directly or indirectly based on the productivity of this one place. Such complex relationships to the resources of the earth have existed only during the last hundred years of human history.

Routes of Travel and Transportation. These great concentrations of urban people engaged in the varied activities of commerce and manufacturing are closely related in their location and growth to the routes of travel and transportation. But the kind of routes selected for horse-drawn wagons, or the ports selected for the accommodation of relatively small sailing ships are not necessarily the same as the routes and ports which would be selected in an era of railroads, motor trucks, and large ocean ships. In many instances the existence of an established commercial center has forced the railroads to follow routes which otherwise would not have been selected; and there are many examples of smaller market towns now decadent because of the shift of the routes of travel to other places.

The factors which lead to the selection of a particular route for a highway are numerous, and vary with the culture of the people. In

[1]Chauncy D. Harris, "The Ruhr Coal Mining District," *Geographical Review*, Vol. 36 (1946), pp. 194–219.

Signal Corps Photo

FIG. 72. *One of China's passable but somewhat dangerous motor roads*

general, men seek the shortest route from starting point to destination, but they swerve from the straight course to avoid obstacles. Some people, like the Romans, are accustomed to building very straight roads, and are deflected from the shortest lines only by the most serious obstacles; while other people's roads wind this way and that in obedience to the slightest local advantages of travel. Roads are fixed at either end on the surface of the earth, and, to a greater or lesser degree, at other critical points along the way—for example, at passes or low points in hilly country, or at river crossings. In crossing an upland the route which requires the least ascent and descent is usually chosen, but not uncommonly this is modified by the selection of the easiest approaches. To people crossing a river, firm landing places on either bank are fully

as important as shallow water. At such points the roads are fixed in position; but in between they conform to slight local advantages of grade or to stretches of dry soil. In most parts of Europe the natural lines of travel for people on foot or with horses were discovered and utilized by the earliest inhabitants.[1]

Surface features, however, are not the only controls of the road pattern. In many regions the road patterns conform to an arrangement prescribed by the survey of land properties. Whether the property lines conform to the pattern of roads, or the roads assume a pattern determined by the survey of properties, depends on which of these two things came first. The main highways in Europe usually antedate the property lines, and, in fact, form the skeleton to which the latter are articulated. The secondary roads, however, are in many instances fixed in position by the land divisions.

Quite different is the pattern of settlement based on railroads. The route selected for a railroad may or may not follow a route previously selected for a road. By making use of cuts, fills, bridges, and tunnels, a railroad can follow a less devious course through hilly country than can a road, and it is deflected less by swamps and rivers. But because railroad grades cannot be so steep as those of roads, the rail routes are tied more closely to the major advantages of terrain than are the highways.

The location of ocean ports, too, has been affected by the new technologies of transportation. Generally it is desirable to establish ports for seagoing vessels as far inland as possible. Many of the larger commercial cities of Europe were located originally at the heads of navigation for sailing ships. Places like London, Paris, Bremen, and Hamburg are now beyond the reach of large ocean liners; so they make use of out-ports such as Southampton, Le Havre, Bremerhaven, and Cuxhaven. Smaller ships can still reach all these big cities, but the river ports are too crowded to accommodate more than a small fraction of the huge volume of shipping of the modern era.

World Distribution of Railroads. The present world pattern of railroads is the product of only about a century, yet it reveals strikingly

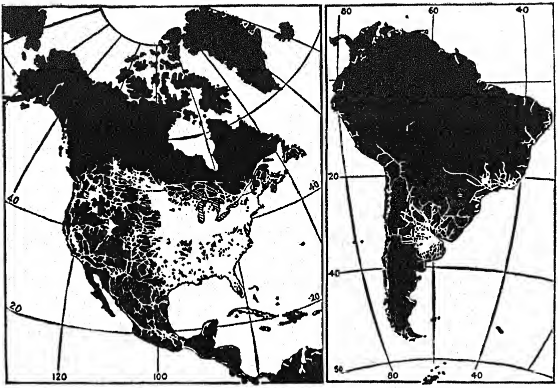
[1]Gordon East, *An Historical Geography of Europe*, London, 1935.

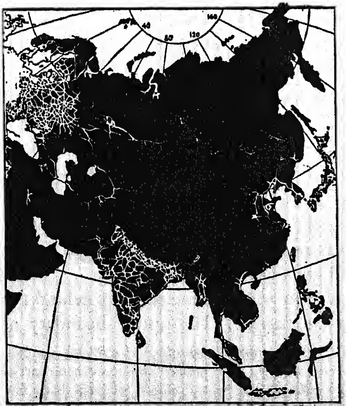
the present-day distribution of what we call Western civilization. The first railroad was built in 1825. Since that date the strands of the railwebs and railnets have been woven into a closely knit fabric near the great Occidental cities. Away from these cities the fabric has a looser weave, until outside the chief areas of Euro-American settlement only long, isolated tentacles have been extended. This present-day pattern is shown on the maps (Figs. 73–74).[1] On these maps a zone of ten miles on either side of the railroad lines has been left white. While the actual zone which the presence of a railroad may affect varies with the nature of the terrain, ten miles is a convenient average. Western Europe and eastern North America stand out conspicuously with their closely woven railwebs; other centers of Occidental occupance, chiefly in the different parts of Groups III and IV, are distinguished by interrupted railwebs or railnets; but beyond the parts of the world dominated by the machine culture the rail lines are few and far between. China possesses a net of the loosest weave, and even that is the result of European activities. The railroad is a distinguishing trait of Occidental culture, and its distribution is an excellent measure of the spread of that culture. The importance of the European regions of Group IV in terms of rail transportation is obvious.

The Significance of Barriers. What constitutes a barrier to transportation? What features of the terrain are important because they impede or prohibit the circulation of people and goods, or because they offer advantages of military defense? The answer cannot be given without reference to the kind of human society which is present. The search for terrain features which would be advantageous as political boundaries is something which has been of concern in Europe during all the centuries since political boundaries were first drawn.

France, for example, was able to achieve national unity behind the protection of a series of physical barriers. The eastern boundary of

[1]Mark Jefferson, "The Civilizing Rails," *Economic Geography*, Vol. 4 (1928), pp. 217–231. Professor Jefferson suggests the terms adopted here: *railweb* indicates that no part of an area is more than ten miles from a railroad; *interrupted railweb* indicates that a few patches more than ten miles from a railroad exist; *railnet* describes a wider spacing of the railroads in which each twenty-mile zone appears as a distinct band; *rail tentacles* are the isolated lines extending into territory otherwise lacking rail facilities; and *riverlinks* are those detached bits of railroad connecting two sections of a navigable stream.





© Mark Jefferson

FIG. 73. *Areas served by railroads.* (Prepared by Mark Jefferson)

France took advantage of the Alps, the Jura, the Vosges, and the Ardennes, along which lines of defense could be maintained against the east (Fig. 68). The fact that there were gaps between each of the hilly or mountainous areas, and that the plains offered easy access around the western end of the Ardennes, has long been of strategic importance to France. In war after war, important and critical battles have been fought in the strategic area between the Ardennes and the sea.

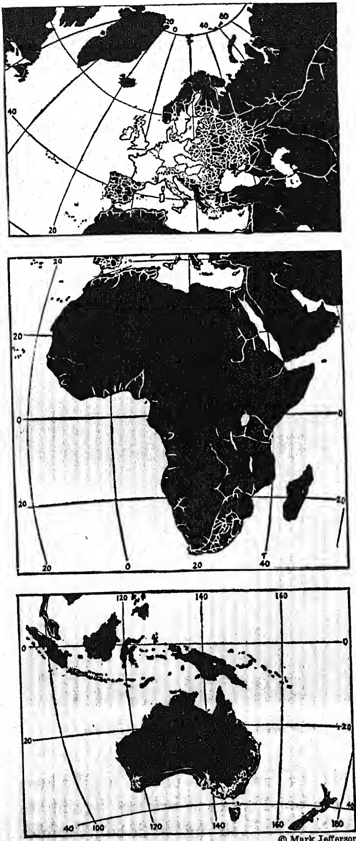
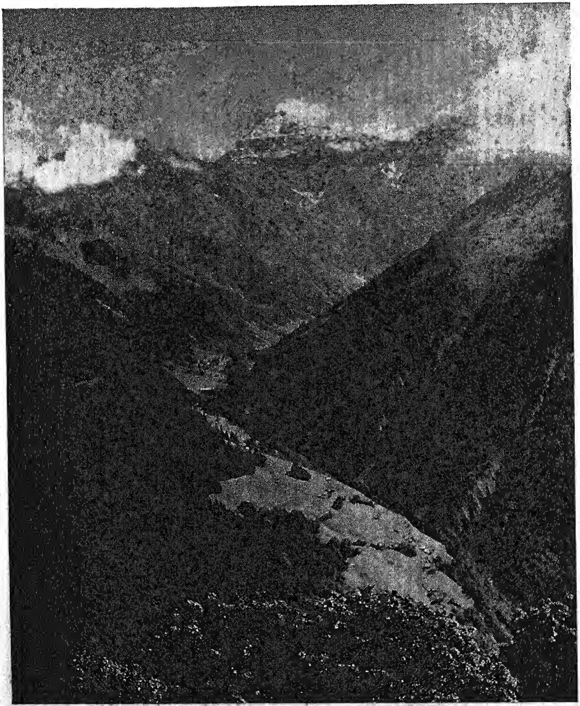


FIG. 74. *Areas served by railroads.* (Prepared by Mark Jefferson)

The nature of modern warfare, like the nature of peaceful economic pursuits, has so changed in this period of changing technology that the significance of the terrain is now very different from what it was even during World War I. No longer are ridges and hills of such importance as strong points in defense as they were in that war and earlier wars. With mechanized armies moving rapidly in motor vehicles, the existence of paved roads is more important than the existence of commanding heights. Actually a larger force may be needed to guard the movement of an enemy along paved highways in hills than in level plains because of the many hidden places along the winding roads of the uplands. World War II demonstrated the ease of military movements in the Ardennes, a region long considered as a major strategic barrier. Strong points of defense in that war were



Three Lions

FIG. 75. *The Swiss Alps have long been barriers to transportation*

offered by the stone houses and narrow streets of the small towns where roads came together and around which it was not possible to pass without leaving the roads. Now, with the use of air-borne armies and rocket projectiles, the significance of terrain must be interpreted anew.

The Political Units of Europe. Unfortunately the people and resources of Europe are divided among some twenty sovereign states, and the boundaries between these states are matters of the greatest significance to the people. The rise of the spirit of nationalism accompanied the rise of the industrial society, and, in fact, was largely produced by it. Yet one of the basic contradictions of Occidental thought at the present time is the existence of ideas of international economic interdependence along with ideas of national economic self-sufficiency and international political irresponsibility. The continent of Europe has the physical resources, the technological skills, and the man power to form one of the major aggregates of economic power on the earth, comparable to that of the United States, the British Commonwealth of Nations, and the Soviet Union. But Europe is split into separate states, plagued by the fear of foreign aggression, hampered by the urge to achieve economic self-sufficiency, and dominated by the hatreds engendered in two great wars.

Because of the importance of political units in the current period—because, whatever may be our aspirations, the fact is that in the immediate future aggregates of economic and military power within political areas are basic realities that cannot be overlooked—we must analyze the problems of population and the relation of people to the land in terms of national territories. Political geography is a field which attempts to analyze the significance of differences from place to place within political areas, and so to draw conclusions concerning the economic or military capabilities of states. As two examples of the methods used in making such analyses we shall consider in turn the geographic structure of France and of Germany.

France. From behind the string of physical barriers which once offered a degree of protection from invasion, the nation of France emerged from the medieval period. The strongly marked national character of France was not easily created. It is the product of centuries of struggle during which the many separate and contrasted regions of the country were brought together in a closely knit political entity. The map suggests the variety of kinds of country existing in this area (Fig. 68). There is the warm, sunny Mediterranean coast, the

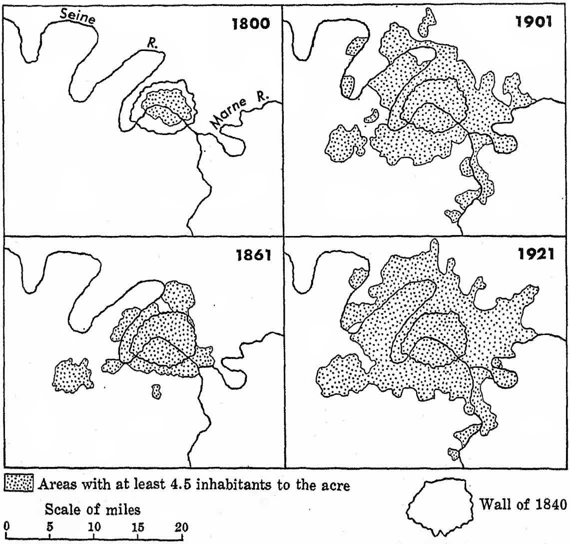


FIG. 76. *The growth of Paris.* (After Gallois)

rugged Alps, the rounded, hilly lands of the Massif Central, the cool, rainy hills of Brittany, the limestone areas where surface water is not easy to find, and the flat, muddy plains of Flanders. Physical differences are matched by differences of dialect and differences of product. The question is raised again and again for each generation of Frenchmen: is this diversity to be a source of strength or of fatal weakness?

Paris is the one great urban center of France. When the Industrial Revolution came to France, Paris had achieved its political and social conquest of the rest of the country. Its commercial conquest was never in doubt. At first its growth was small, for the outline of the city in 1800, shown on Fig. 76, was the result of many centuries of slow population increase. When the fortifications of 1840 were built around

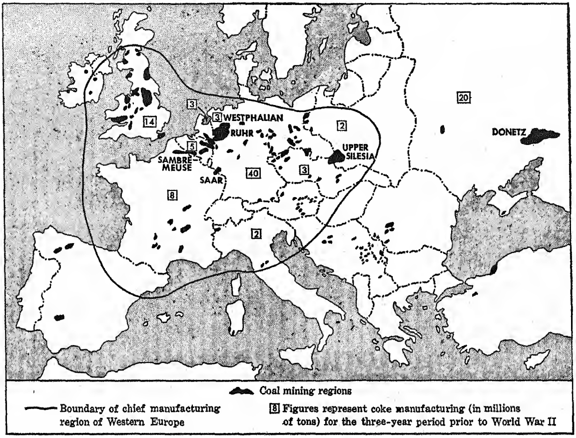


FIG. 77. *Coal mining regions and coke production of Europe.* (After Chauncy D. Harris)

the city they included a built-up area only slightly larger than that of half a century earlier, and there was nothing beyond. But the fortifications were soon overrun by the expanding city. They have now been leveled and used for the fine boulevards which surround the central part of Paris. By 1861 the city had more than a million inhabitants. By 1901 the urban area had expanded up and down the Seine Valley; it had invaded the valley of the Marne, and toward the west it had almost reached the formerly separate Versailles. Today the metropolitan area, which is much larger than the political city, includes a number of once independent municipalities. Paris has become the primate city not only of France but, to a certain extent, of all the countries whose people speak any of the Romance languages.

Meanwhile France in the industrial society was not so well off in terms of economic and military power as it had been in the pre-industrial society. The country possesses excellent and varied agricul-

tural lands, and it is more nearly self-sufficient in terms of food than is Great Britain. In the pre-industrial world France had the agricultural production to support a numerous population, and it had the advantages of easy communication along its fine rivers to lead to the development of commerce. But as an industrial power it is handicapped by the lack of coal. To be sure, France possesses large resources of iron ore in Lorraine; and it has large quantities of potash and bauxite (the ore of aluminum). But the lack of coal meant that in the early days of industrial development in Europe the iron-and-steel-manufacturing centers were in other countries, although a lesser steel industry was set up in Lorraine based on imported Ruhr coal. Industries made use of France's meager supplies of coal in the north along the Franco-Belgian border, in the Massif Central, and in the Rhône Valley around Lyon (Plate 21). A great variety of industries were built on the outskirts of Paris, where the necessary raw materials and fuels could be brought by rail and river boat. France utilized its water-power resources for electricity, and by this means in part compensated for the scarcity of domestic sources of coal. The industrialized areas, however, are mostly located in relatively vulnerable positions from the point of view of military attack.

The import of essential industrial raw materials and fuels was paid for in part by the export of numerous agricultural specialties. France has long been famous for its wines; the various contrasted districts of France have given their names to such well-known types of wine as Burgundy, Bordeaux, Champagne, and others. Other districts have become equally famous through the production of specialized types of cheese, such as Camembert. Most of France is devoted to the raising of wheat, and of grapes and other fruit. In the south there is a narrow zone of wheat and maize farming; and in the north, from Brittany into Belgium, the land is used chiefly for dairy cattle, hay, sugar beets, and apples (Fig. 78).

France was the first country of Europe to reach a static population. In the early eighteenth century, before the beginning of the Industrial Revolution, France had the largest population of any country of Europe. Its favorable soils and location in terms of the pre-industrial society gave it strength in terms of population density. But the significance of

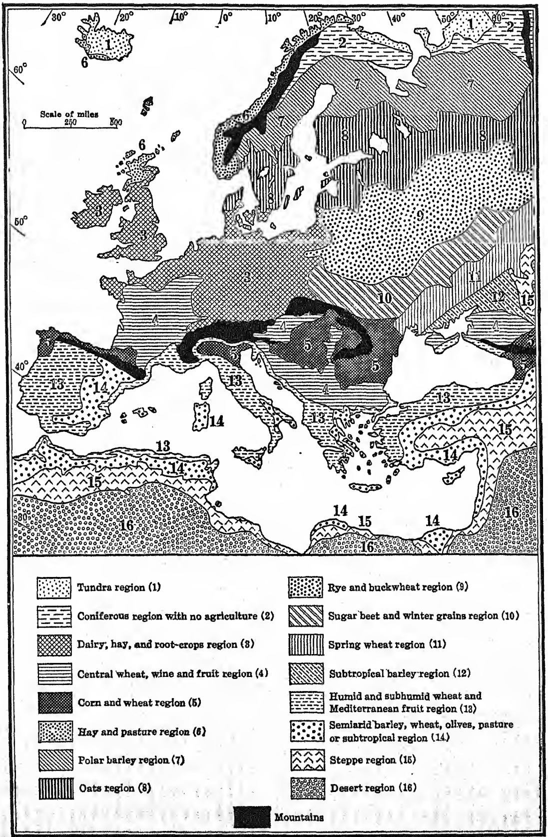
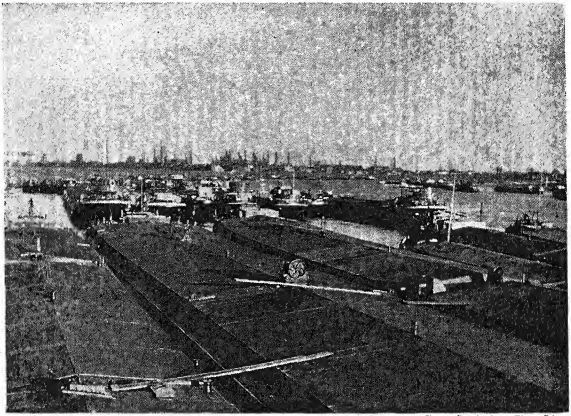


FIG. 78. *Agricultural regions of Europe.* (After Olof Jonasson)

soil and location changed with the advent of the industrial society, and France dropped behind. The population of Germany passed that of France about 1870, that of the British Isles about 1900, and that of Italy in 1930. Meanwhile France's population would have actually declined during the period between World Wars I and II had it not been for a considerable current of immigration from North Africa and from other parts of Europe. The population was about 41,900,000 in 1936, and 41,200,000 in 1945; it is estimated that by 1955 it will have dropped to 40,300,000, and by 1970 to 36,900,000. France is a country which has gone through the period of increase associated with the arrival of the industrial way of living, and has reached stability at a new level of density. In other words, France is demographically mature. Production is more restricted by man-power shortage than by lack of raw materials. France has scarcely the man power needed to maintain the remnants of its once extensive colonial empire, especially as the possession of most of its colonies is a financial liability rather than an asset.

All France's current intentions, capabilities, and unsolved problems must be interpreted against this background of land and people. Lack of coal is not necessarily a weakness; there are other kinds of specialized production that can bring substantial income and can pay for necessary imports. Dense and rapidly increasing population is not necessarily an asset; there are many advantages for the country which has achieved a stationary population. France suffers from the idea of nationalism (which the French themselves were among the first to develop) not because the love of country is bad, but because the love of country in an industrial society must be illuminated by an understanding of the fact of international interdependence and responsibility. France as an integral part of a federated Europe would be very well off indeed.

Germany. Germany is another country the territory of which is made up of a great variety of contrasted parts; but Germany, unlike France, had no protection along its borders during the early centuries of European settlement. The barriers within the country were greater than those around its margins. It was crossed from east to west and from south to north by major routes of travel. Meanwhile the Germans themselves were pushing eastward at the expense of the Slavs. The



Fenno Jacobs from Three Lions

FIG. 79. *Belgian and French barges awaiting a cargo of coal in the Ruhr district*

German advance followed two chief directions: northeast and southeast. Germans moved along the south shore of the Baltic, establishing commercial towns in the midst of rural areas still solidly occupied by Slavic peasants. A German colony was established even as far east as the Volga River (Fig. 69). The German advance was also channeled down the Danube. Meanwhile Slavs remained solidly entrenched behind physical barriers such as the marshes of western Poland or the wooded ramparts of the Erzgebirge and the Böhmerwald (Bohemian Forest) (Fig. 68).

The industrial society developed very rapidly in certain parts of Germany. The great Ruhr industrial district, as we have seen, was built between 1850 and 1913. With this enormous natural resource, Germany developed during this period as the economic heart of Europe. It absorbed a large share of the exports and supplied a large part of the imports of the countries on its borders, and of those farther away to the northeast and the southeast. To some countries, such as Latvia, Estonia, Hungary, Yugoslavia, and Bulgaria, Germany supplied more than 30

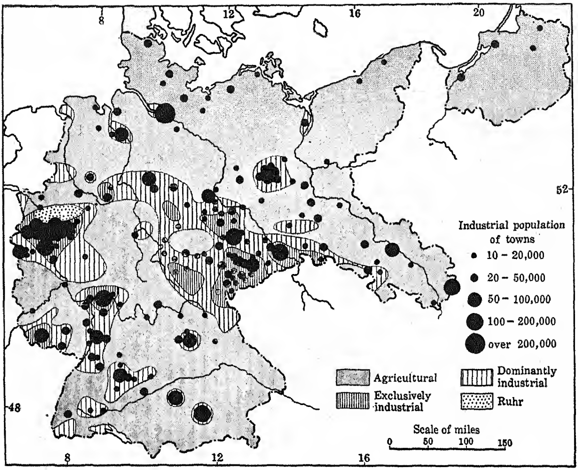


FIG. 80. *The industrial regions of pre-war Germany.* (From R. E. Dickinson "The Economic Regions of Germany," *Geographical Review*, Vol. 28 (1938), pp. 609–626)

per cent of the total imports and took from them a correspondingly large proportion of the exports in the period before World War II. Other countries, including some with even a smaller proportion of total trade with Germany, were dependent on German coal. No decisions of foreign ministers and no decrees by persons in political power can change the stubborn geographic fact that the Ruhr includes half the coal of Europe and an even larger proportion of the high-grade coking coal. All Europe is dependent on the Ruhr.

Industrial development within Germany was not restricted to the Ruhr. There was also the smaller, but significant, Silesian Industrial District on the former border of Germany and Poland. There was the Saar District, so much desired by France on the border of which it is located, but so stubbornly German in sentiment. The Central Industrial District of Germany was developed between Hannover and Leip-

Fenno Jacobs from Three Lions

FIG. 81. *Many workers are needed to harvest Germany's huge potato crop*

zig, based in part on the utilization of large supplies of lignite, or brown coal, which could be used for the chemical industries and for the generation of electric power. The Ruhr, in 1937, produced 68 per cent of Germany's coal and 73 per cent of Germany's steel, but there were many other types of industry which were developed, in part for strategic reasons, in areas not previously industrialized. Germany led the way in the use of new technologies for the manufacture of all sorts of things from substitute materials. Lacking most of the necessary industrial raw materials, such as iron ore, ferro-alloys, bauxite, and many others, the Germans discovered ways to make new substances from wood and coal. By complex industrial processes, even petroleum and rubber were made to compensate for the lack of access to sources of the natural raw materials. Germany's defeat in World War II was not due to lack of raw materials.

Germany also had a large food-producing area. Although it lacks the variety of French farming areas, it did produce more of the basic necessities in the prewar period than did France—wheat, barley, rye, and potatoes. Most of Germany's surplus food-producing areas were located in the east.

Political unification came to Germany much later than to France. Not until 1870 were all the separate political units brought under one national government. Even then, however, the basic diversities of Germany had not been reconciled. The industrial society was firmly established in the west; but the east, especially the powerful state of Prussia, remained essentially pre-industrial in economy and political outlook. The industrial part of Germany provided the economic and military power; the pre-industrial part provided political and military leadership. Only a strong central government could hold such diverse groups together. The result of this effort to combine the industrial and the pre-industrial was disaster not only for the Germans but for all the rest of Europe, and perhaps for Occidental society itself.

Before World War II Germany included an area of 181,699 square miles, and had a population of about 67,000,000, which had increased to 69,500,000 in 1940. This large population was the result of very rapid expansion during the latter half of the nineteenth century. Until 1910 Germany had the highest birth rate of northwest Europe; but by 1933 it had one of the lowest. In spite of the Nazi policy of urging an increase in the birth rate, the German population was about static in 1939. It was estimated that by 1955 the population would have reached a peak of 72,200,000, and thereafter would have declined to about 69,800,000 in 1970. As a result of the war, however, Germany lost all its territory east of the Oder and the Neisse; its area is now about 142,000 square miles. Germans moving back into Germany from areas farther east have raised its total population to about 71,000,000. By 1955 its population will have increased slowly to about 73,000,000, but it may have declined below this figure by 1970.

With Germany defeated, the victorious nations face a difficult policy decision. All of them hope to remove the fear of another war of aggression from this source, and for this reason it is desired to restrict the rebuilding of German industries. Yet the output of the German industries and that of the German coal mines are needed for the reconstruction of Europe and for the maintenance of a high level of living in that continent. German coal is so located that it cannot easily be incorporated in the territory of another state; yet to leave it to the unrestricted use of the Germans could mean a renewed war effort. Moreover,

German industrial skills are needed, and any attempt to reduce the level of living of such a large number of people as make up the German industrial population to the level of subsistence farming would inevitably depress the living standards of all the other parts of the continent. The fact of interdependence is a reality which cannot be avoided, but too many people are still thinking in pre-industrial terms.

NORTH AMERICA

The third of the three major areas of Group IV in the world is in eastern North America. The mid-latitude mixed forest lands of North America are only a little smaller than the similar regions of Europe, but they are occupied by a much smaller population. Within these regions in Europe there are thirteen cities with more than a million inhabitants; in North America there are ten such cities. In Europe the density of rural population is generally more than 100 people per square mile; in eastern North America the density is mostly between 25 and 50. But the North American area stands foremost in the whole world in terms of productive capacity, and so in the living standard of its people (Plate 1).

In some ways the eastern part of North America is remarkably similar to western Europe. As Carl Sauer points out "it would be impossible to cross an ocean anywhere else and find as little that is unfamiliar on the opposite side."[1] The mid-latitude mixed forests of both areas contain many of the same kinds of trees. The climate of both areas is characterized by variable and stimulating weather, and by an abundant, but not excessive, supply of moisture. To be sure, the winters of eastern North America are colder than those of western Europe, and the summers are hotter; but the difference is not so great that important changes in clothing or housing were necessary. The surface of the land, too, was familiar to the Europeans—there are similar landforms resulting from geological processes already observed in Europe. And there is the further element of similarity, which became important after the emergence of the industrial society, in that both parts of the world are abundantly supplied with coal.

[1]Carl Sauer, "The Settlement of the Humid East," in *Climate and Man*, Yearbook of the U. S. Department of Agriculture, 1941, pp. 157–166.

In certain other respects, especially with regard to the process of settlement, eastern North America and western Europe are very different. The aboriginal inhabitants of eastern North America were few, and they were almost completely eliminated by the invading Europeans. Several European countries were involved in the colonization of North America: there were the Spaniards, who, because they avoided the humid forest areas, were not important in the regions of Group IV; there were the French, whose search for furs spread them thinly over the great interior of the continent, but who formed concentrated agricultural settlement only along the lower St. Lawrence Valley; and there were the Dutch and English, whose compact colonies along the eastern coast provided the settlement base from which pioneers carried the European way of living westward across many different kinds of land to the Pacific. The Dutch were eliminated as a result of wars fought in Europe; and thirteen of the English-speaking colonies, after declaring their independence, succeeded against odds in forming a single nation instead of thirteen separate and sovereign nationalities. The industrial society, therefore, came to America at a time when there were two conditions in the New World which were not to be found in the Old World. One was the presence of a rich endowment of natural resources in a land essentially unoccupied. The other was a wide area of unrestricted commerce within the boundaries of one nation.

The Settlement of North America. The first colonists came to America not to raise crops, but to trade and fish. The products they wanted to send back to the homeland included furs, fish, spices, dyewoods, and naval stores (tar, pitch, turpentine, resin, etc.); and, of course, precious metals and jewels, if these could be found. Only after many attempts to maintain colonies with food brought from Europe did the settlers in the New World turn to the production of crops.

When they did begin to raise their own food, they adopted the crops and farming methods of the Indians. Throughout eastern North America they based the agriculture on the Indian grain—maize; and along with maize they used squash and beans. Also, instead of following the traditional European practice of clearing each field of its trees and stumps before plowing, they used the Indian technique of girdling

Fig. 82. *Eastern North America*

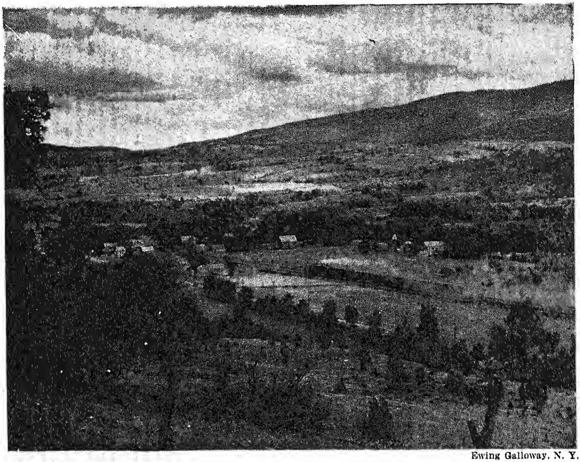

Ewing Galloway, N. Y.

FIG. 83. *A settlement in the hilly upland of New England*

the trees, and they planted their crops in irregular hills among the stumps. This kind of farming caused endless criticism from European travelers, accustomed to neat fields with crops planted in rows; but it persisted for more than two centuries wherever subsistence farming was practiced.

The early colonies along the Atlantic seaboard were notably different with regard to the basic patterns of occupance. In New England, settlement was usually in the form of compact villages, from which farmers went forth to cultivate the surrounding lands. The widespread literacy, the interest in educational matters, the development of such democratic institutions as the town meeting could appear in places where people live close enough together, but not so easily where they are widely scattered. The dispersed pattern of rural settlement of the "middle colonies" (New York, Pennsylvania, and Maryland), where families lived on isolated farms, made community life more difficult.

In the southern colonies the plantation system was adopted, with homes of the many workers clustered about the mansion of the wealthy landowner, who alone could afford the services of a tutor for his children.

The southern colonies were the first to adopt commercial agriculture. Into Virginia the colonists brought tobacco seeds, probably from the West Indies by way of England. Just at this time the English were learning to smoke, and the Virginia colonies achieved great prosperity by supplying tobacco to the home market. Cotton was introduced into the southern colonies through Charleston, in South Carolina, and its cultivation on large plantations was also made profitable by the English market. Because commercial agriculture was so profitable, many more workers were needed than could be supplied by the colonists themselves, and so they began the importation of Negro slaves. The South began to appear as a distinct economic and social region.

The Pioneer Movement. Not far inland from the colonies along the east coast, the Appalachian Highlands imposed a barrier of forested hills and low mountains which impeded westward migration (Fig. 82). The French, who settled along the St. Lawrence, found an easy route inland, and following the Great Lakes they crossed easy portages to the headwaters of the Mississippi. Over the vast interior of North America they spread a thin net of trading posts. Many of the large cities of today—such as Chicago, Detroit, and St. Louis—originated as French trading posts. Dutch settlements had spread up the Hudson Valley, but when the English received New Amsterdam they found the way westward through the Mohawk Valley stopped by warlike Indians and hostile French traders. The English colonies expanded laterally parallel to the coast until, by the early eighteenth century, there was a continuous belt of settled country all the way from Massachusetts to the Carolinas.

The first westward movement originated in the middle colonies. The pioneers crossed the Appalachians by two chief routes: by the Susquehanna and Juniata rivers to the headwaters of the Ohio, and thence down the Ohio by way of Pittsburgh as far as the Mississippi; and by the Cumberland Gap to the Blue Grass Basin of Kentucky and the Nashville Basin of Tennessee. After the Mohawk Valley had been

cleared of Indians and the canal had been built from Albany to Buffalo, in 1825, there was a strong movement of pioneers from New England and northern New York into the region of the Great Lakes. In the south, also, pioneer settlers were moving westward, chiefly into Kentucky from Virginia, and from the Carolinas and Georgia around the southern end of the Appalachians to the Mississippi. Eventually these westward movements, supported by a tide of immigration from Europe, pushed on into the grasslands to the west (Plate 10) and initiated one of the most remarkable periods of economic history—a story we shall tell in connection with the regions of Group V.

Patterns of Population in Eastern United States. The patterns of population which have emerged in the modern period must be described in terms of their origins in the early colonial period. The fact that the first stream of pioneers to cross the Appalachians came from the middle colonies accounts for the patterns of rural settlement developed throughout the Middle West. The dispersed pattern of farms, the large barns detached from the houses, even the basic "corn-hog" type of farming, came from the English, German, Scotch-Irish, and other colonists of the region between New York and Maryland.

The details of the pattern of settlement vary from place to place. The series of block diagrams (Fig. 84) suggests certain characteristic relationships of settlement and underlying terrain that can be observed at many places in eastern United States (except that the rectangular patterns are found only in those areas settled after 1785). Where the valleys are narrow and V-shaped, they are commonly left in forest, whereas the roads and farms are concentrated on the level uplands. In some regions there are discontinuous bits of valley flats along the river with small settlements on them, but the larger area is still on the more continuous uplands. There are other cases where the uplands are discontinuous, but the valley bottoms are the chief farming areas. And there are cases where the uplands are too steep and narrow-crested to permit much settlement.

Along the floodplains of large rivers, such as the Mississippi, the pattern of settlement is likely to take on a crescentic arrangement in harmony with the arrangement of somewhat higher ground along the

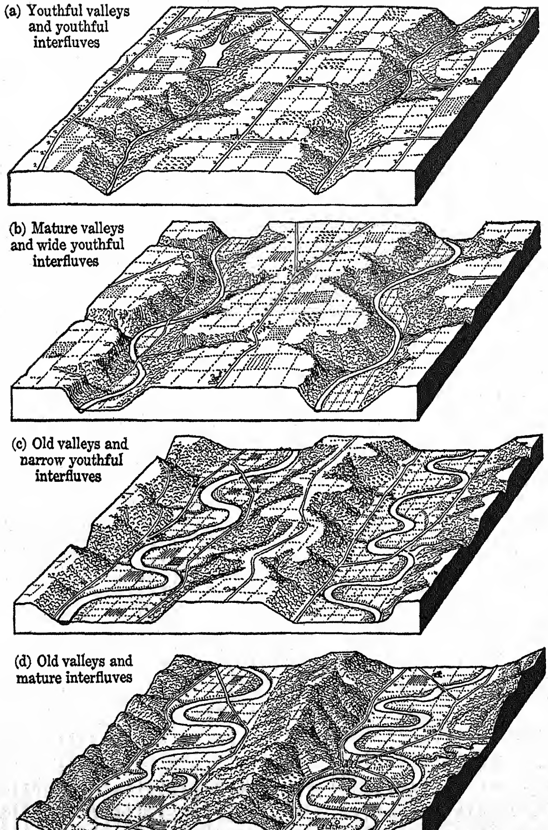


FIG. 84. *Relation of occidental settlement to landforms*

immediate river channel or former channels (Fig. 86). The farm patterns on the valley bluff which marks the edge of the floodplain and on the higher country back from the river are quite different from that of the river bottoms, a fact which can be observed strikingly from the air. In the United States, where maize rather than rice is the chief grain crop, the floodplains of the rivers are thinly settled, and there are many more people on the higher ground away from the rivers. In a similar situation in China, the rice-growing Orientals have developed the opposite patterns of settlement, concentrating on the floodplains rather than on the country away from the rivers. Furthermore, the chief towns along the larger navigable rivers, which occupy sites perched on the valley bluffs safe from flood waters, nevertheless have been located at places where the river in its meandering swings against the base of the bluff (Fig. 87).

Settlement in eastern United States, as in most Occidental regions, was first established along the main pre-existing lines of travel. The Indian trails and the rivers which were navigable for canoes were the first routes along which settlement advanced. The map of Michigan (Fig. 85) shows the relation of the Indian trails to the terrain, and suggests the extent to which the aboriginal pattern of settlement focused on the same points which later emerged as great cities. Detroit owes its location to the existence of firm gravelly banks which permitted easy landings on both sides of the Detroit River. The Indians used it so frequently that the French placed their trading post there. Many of the main automobile highways of the present day follow very closely the routes first laid down by Indians on foot.

In 1785 the Federal government of the United States adopted a uniform pattern of land survey—a rectangular pattern based on square mile sections (Fig. 116). In most parts of the country settled before 1785 there are irregular field boundaries and winding roads. The parts of the country settled after 1785 are dominated by the right-angle pattern, oriented to the cardinal points of the compass. However, in many parts of the forested regions, the first routes of penetration were still the Indian trails, which conformed to no systematic pattern. Main roads, therefore, in many cases cut at an angle across the north-south or east-west roads. The basic pattern, too, is interrupted in places by such

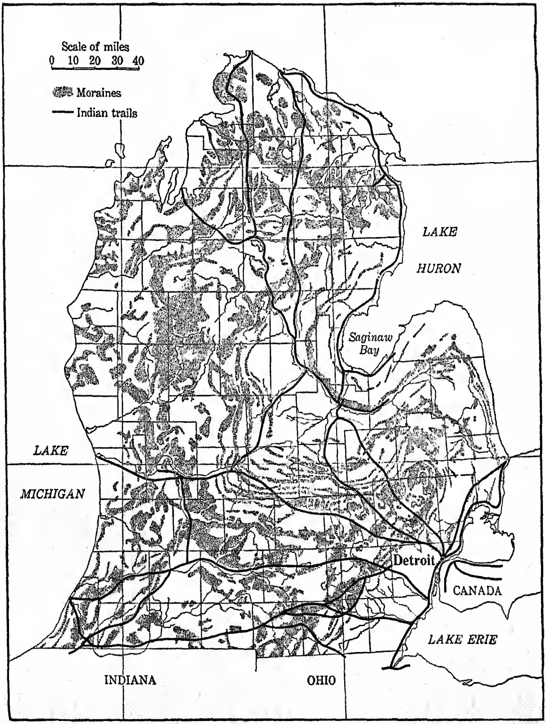
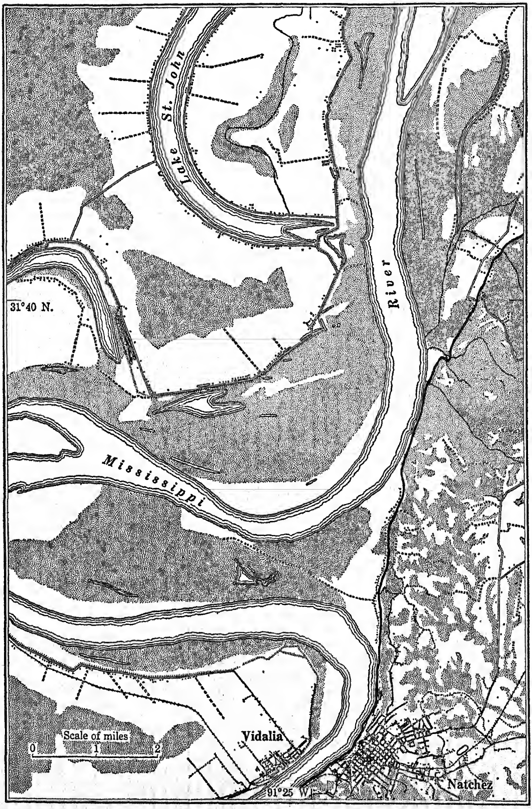


FIG. 85. *Moraines and Indian trails of Michigan.* (Moraines after Leverett and Taylor; Indian trails after Hinsdale)



Forested areas — Edge of floodplain — Levees

Fig. 86. *Topography of a floodplain.* (From the Natchez Quadrangle, Mississippi, United States Geological Survey)

natural obstacles as lakes, swamps, rivers, or steep slopes. A detail which illustrates these features is shown on the map of Perham and vicinity in Minnesota (Fig. 88).

The pattern of people in the state of Pennsylvania shows to what extent population and settlement are fitted to the underlying terrain (Figs. 89 and 90). Where the parallel ridges and valleys of the Appalachian Highlands develop a strongly annular arrangement of the drainage, the population reflects this characteristic of the land. West of the Allegheny Front, where the Allegheny Plateau is cut by streams arranged in a dendritic pattern, the population also reflects this condition. Even in the great cities the shape of the terrain is a matter of great significance in the development of the urban structure.

In North America, as in Europe, the first settlements were made in the era of horses, and roads were fixed in accordance with the factors previously discussed. Later, when railroads were built, some notable readjustments were made. The best farm lands in the hilly interior of New England are generally, but not in every case, on the uplands The valleys, filled with sandy and gravelly glacial deposits, are generally

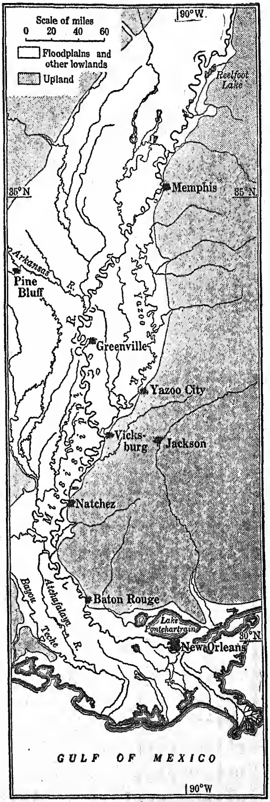


FIG. 87. *A part of the lower Mississippi floodplain, showing location of chief towns and cities*

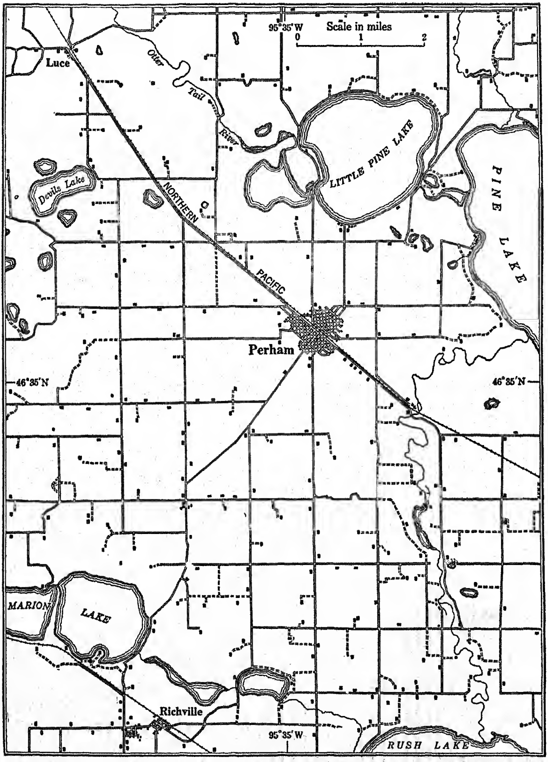


FIG. 88. *Topographic detail in Minnesota.* (From Perham Quadrangle, Minnesota, United States Geological Survey)

poor for agriculture. So the earliest towns were on the uplands—for example, Grafton and Sutton (Fig. 91), on either side of the Blackstone Valley in Massachusetts. The situation at that stage was not unlike the conditions shown hypothetically on block c of Fig. 84, except that the valley bottoms were unoccupied because they were too sandy. When textile industries first appeared in New England they were placed at small water-power sites, such as Millbury. And later the railroads ran through the valleys to avoid the steep grades by which the uplands were reached. Millbury grew; but Sutton and Grafton became sleepy little villages until summer visitors from the large cities not far away came to them for summer homes. In many instances hill towns have declined or disappeared. But the new towns along the railroads have prospered. There are examples of whole communities which have been moved downhill into the valleys. There are other examples of towns which have been extended to near-by railroads, such as Princeton, Illinois (Fig. 92), where the result has been the development of two trading centers.

Agricultural Regions. Only gradually have the present agricultural patterns of eastern North America made their appearance. At first there was very little difference between one place and another. The European grain crops were tried, but very quickly the colonists adopted both Indian crops and Indian methods. In the course of time, however, certain areas became differentiated from other areas in terms of agriculture. Near the great cities, today, there are concentrations of truck farms and dairy farms. Almost all New England, New York, and Pennsylvania supply fluid milk to New York, Boston, and Philadelphia. In other places there are highly specialized areas where the farmers have found the physical conditions especially well suited to the production of one product; for example, the potatoes of Aroostook County in Maine, the cranberries of Cape Cod, the tobacco for cigar wrappers of the Connecticut Valley, or the orchards and vineyards of the shores of Lake Ontario, Lake Erie, and Lake Michigan. The Corn Belt, which is one of the major agricultural regions of the United States, has its eastern end in the previously forested areas of Ohio, but its greatest development is in the grasslands farther west. South of the Corn Belt the farms

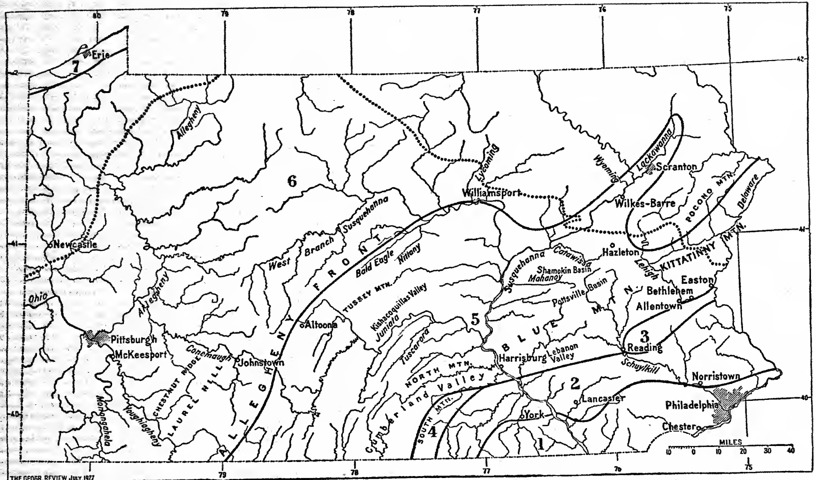


Fig. 89. *Surface divisions of the state of Pennsylvania.* 1 and 2, Piedmont; 3 and 4, Blue Ridge; 5, Appalachian Ridges and Valleys; 6, Allegheny Plateau; 7, Lake Plain. Southern limit of glaciation indicated by dotted line. (Courtesy of the American Geographical Society of New York)

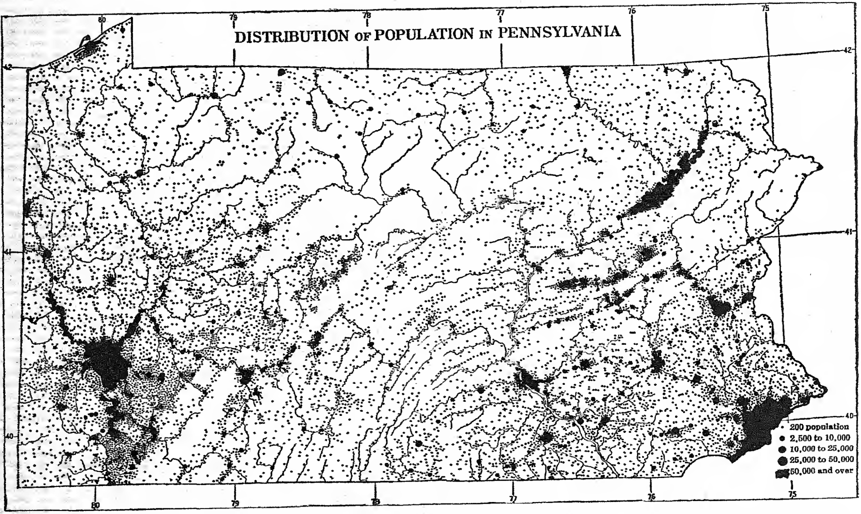


FIG. 90. *Distribution of population in Pennsylvania.* (From a paper by C. E. Batschelet in the *Geographical Review*, Vol. 17 (1927), p. 430)

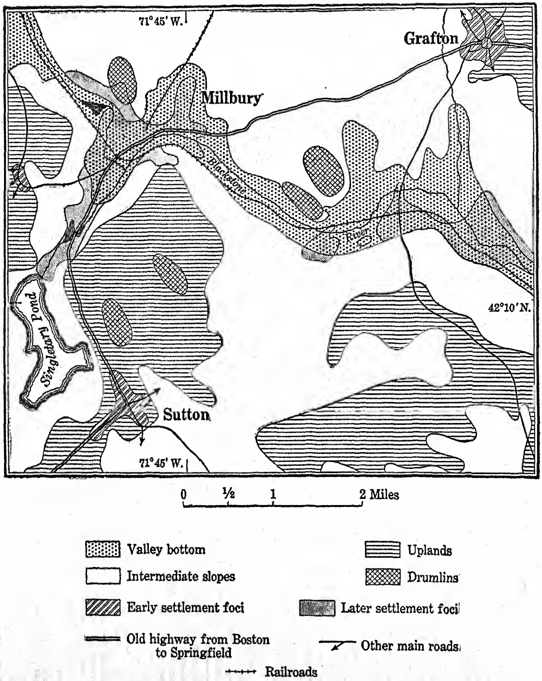


FIG. 91. *Sequence of settlement patterns in Massachusetts.* (A portion of the Blackstone Valley)

of Kentucky and Tennessee raise chiefly maize and wheat, with certain specialized districts devoted to tobacco. Still farther south is the Cotton Belt, which extends from the Carolinas to Texas. Along the Gulf coast and in Florida the long growing season permits the growth of tropical or semitropical crops. There are areas devoted to sugar cane, rice,

and citrus fruits. The factors which have led to the development of the major agricultural regions of North America will be discussed in the chapter dealing with Group V.

Cities and Industries in Eastern United States. Manufacturing industries appeared in the United States shortly after the Revolutionary War. To be sure, there had been small-scale iron smelters and other manufacturing of local significance long before; but New England was the first part of the United States to become predominantly industrial. Now the largest concentrations of industry are outside New England. In the late eighteenth century or early nineteenth century it would have been very difficult to predict what kinds of industry would localize in different places. One could scarcely have failed to predict the pre-eminence of Pittsburgh and Chicago, but none of the other great industrial areas were so obvious.

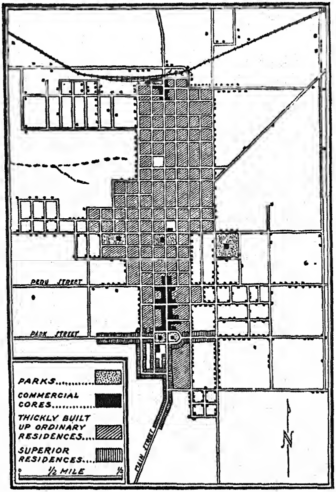


FIG. 92. *Princeton, Illinois.* (After a map by Stanley D. Dodge)

The way in which the human factor operates in establishing the original patterns of industry can be illustrated by the story of the first cotton mills. Many Americans, after the Revolution, wanted to build machines such as they had seen or heard of in England, but no one had been able to build such machines, and the English would not permit their export. In response to a prize offered in Philadelphia for information about textile machines a young man named Samuel Slater came to

America with enough information in his head to reconstruct a workable machine from memory. However, the Philadelphians, with characteristic caution, refused to risk their money on Slater's machine. New Englanders, on the other hand, were ready to back him; and in 1790 the first cotton mill in America was started in Pawtucket, Rhode Island, near Providence. Thus New England rather than Pennsylvania became the leading cotton textile region of the United States because of the attitudes and temperament of the people, not because of any advantages of location.

Furthermore, the distribution of the textile industry within Massachusetts and Rhode Island was the result of unpredictable historical factors. When Slater showed that machines could be built to produce cotton thread, knowledge of steam engines to furnish the power had not reached America. The only source of power was falling water, used directly through a mill wheel to turn the machinery. Since each factory had to be within a hundred feet or so of the mill wheel, there was room for only one factory at each power site, or at the most two, if both sides of a stream could be used. Small water-power sites were therefore just as valuable as large power sites. Along all the New England streams there are numerous falls and rapids, and at each place where a small dam could be inexpensively built, small industrial towns were established around a mill. Industries were scattered all through the valleys of interior New England.

Scarcely thirty years later the significance of these resources was wholly changed. The application of steam power gave an advantage to mills located at tidewater, for the coal had to be imported by barge along the coast. Within a short time, however, railroads, which were built rapidly after 1830, provided adequate connections for all the scattered little industrial towns. Where canals had been started (as in the Blackstone Valley above Providence), they were promptly abandoned in favor of the cheaper railroads. The many small manufacturing towns were therefore able to survive and to this day can be found in the hilly New England interior.

The study of each industrial concentration brings to light a story similar to that of the early New England textile mills. But once a district becomes known for a specialty and skilled workers become available, there is a definite economic advantage for other similar or

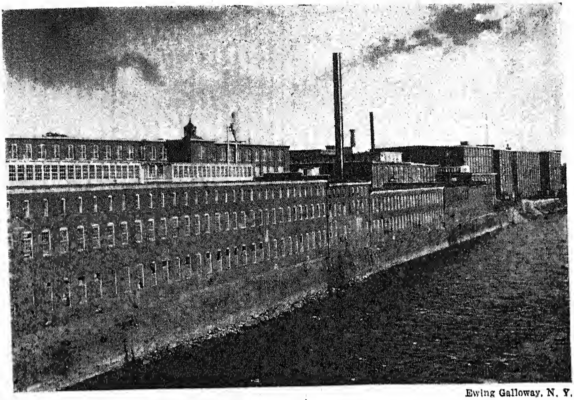


Fig. 93. *A woolen mill at Manchester in the Merrimack Valley*

closely related industries to select the same locations. So it is that the Providence–Fall River area is the chief center of high-grade cotton textiles in New England today, and has survived even the removal to the South of most of the cotton textile industries which require less skill. Woolen textiles are concentrated north of Boston (Fig. 93), and Boston itself is one of the largest of wool depots. Shoe manufacture is localized in eastern Massachusetts. The lower Connecticut Valley is noted for its metal industries and its manufacture of complicated machinery. Holyoke, in Massachusetts, is a center of paper production. In all these industrial districts of New England, which cover less than 1 per cent of the area of the United States, there are about 5 per cent of the people of the United States, and 10 per cent of the manufacturing in terms of value. More than 75 per cent of the people of New England live in towns and cities, leaving large areas of surrounding countryside almost empty of human inhabitants.

Outside of New England other vast industrial concentrations have appeared. One of the world's greatest iron-and-steel-making districts, the Pittsburgh-Cleveland District, is located in western Pennsylvania

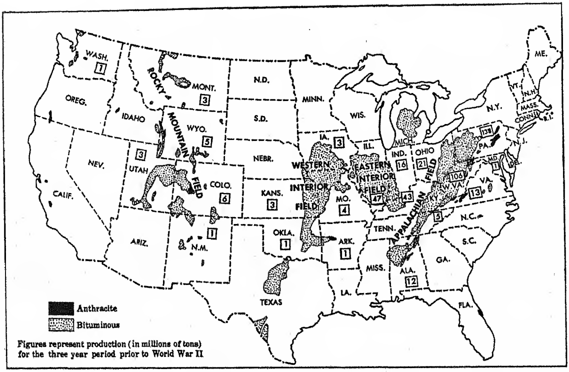
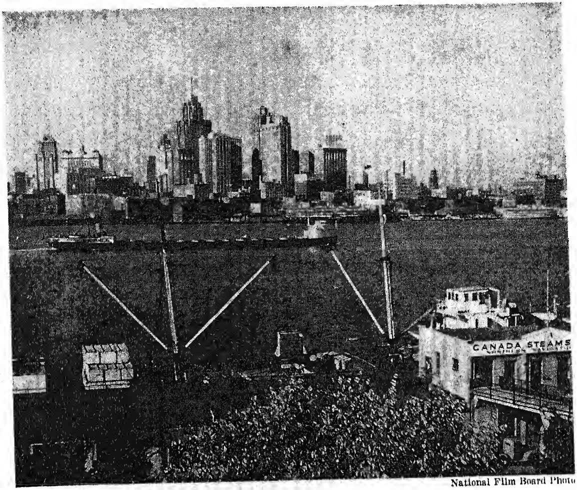


FIG. 94. *Coalfields and coal production in the United States*

and eastern Ohio. Another, the Chicago area, is located at the southern end of Lake Michigan. Coal is supplied to these districts from the Pennsylvania-West Virginia fields, and from the Illinois fields. Iron ore is brought by lake steamer from the great ore deposits of Minnesota and northern Michigan on Lake Superior. Iron ore and coal are also brought by boat and by rail to Detroit, center of the automobile industry (Figs. 94 and 95). Smaller industrial cities and towns, each with a specialized type of manufacture, are scattered widely over New York, Ohio, Indiana, and parts of neighboring states.

Chicago, the second city of the United States, combines both commerce and industry. The advantage of its site, where the position of Lake Michigan produces a focus of the east-west lines of travel, has led to the concentration there of commercial activities serving a wide area of the interior of North America. The geographical city of Chicago extends from Evanston on the north to Gary on the east, and around the huge metropolitan area there is a ring of satelite cities, including Michigan City, Joliet, Aurora, and Elgin.

Throughout eastern United States there are scattered industrial and commercial centers, each serving a distinct portion of the national ter-



National Film Board Photo

FIG. 95. *The skyline of the automobile city of Detroit*

ritory. In the northwest are Minneapolis and St. Paul, the twin cities that face in opposite directions; in the west is St. Louis and Kansas City; in the southwest are Dallas and Fort Worth, and the several thriving Texas ports; in the south is New Orleans; near the southern end of the Appalachian Highlands is Birmingham, an important center of heavy industry based on local sources of iron ore and coal; on the piedmont of North Carolina, supplied with a network of electric transmission lines, are cotton textile industries and tobacco industries.

The great urban centers of the Middle Atlantic region which are located on Chesapeake Bay and Delaware Bay or the navigable rivers that enter those bays have a great advantage over inland cities in the use of imported raw materials. Baltimore is a center of heavy industry—steel, copper, fertilizer, and other manufactures dependent in large part on overseas materials. As the iron ores of the Lake Superior region are

used up, the steel industry in the United States will have to depend more and more on imports of ore from Brazil, Venezuela, and Chile, as well as from North American sources, and this dependence will be to the advantage of Baltimore. Wilmington will also prosper, for its great chemical works utilize many imported materials. Philadelphia is a great commercial and industrial city, manufacturing mostly consumer goods. These ports, including also Norfolk and New York, all of which have the advantage of deep water close to the docks, handle approximately half of all the vast volume of foreign commerce of the United States. This is a focus of the currents of commerce which is similar to that on the North Sea ports of Europe. In peaceful times the greatest volume of commerce in the world passes between these Middle Atlantic ports of the United States and the North Sea ports of Europe.

New York. The primate city of the United States is New York. This is the one urban center which stands out above all others, and in it are concentrated many millions of people, many of the most important skills in the United States, and huge aggregates of financial power. The city performs all the urban functions: it is a commercial and financial center of world-wide significance; it has an enormous concentration of manufacturing industry, chiefly of consumer goods; it is a city which provides recreation for many millions of people from distant places; it is a major center of art, music, and literature; and in recent years it has become the seat of the United Nations organization. On it are focused the interests and hopes of the entire world.

The geographical city of New York extends far beyond the political city. In the east it includes politically independent cities at least as far as the border of Connecticut. It includes Brooklyn, Manhattan, and the Bronx east of the Hudson River. West of the river in New Jersey the metropolitan area takes in Jersey City and Bayonne along the Hudson, and, west of a belt of marshes, Elizabeth, Newark, Passaic, and Paterson. The heart of all this enormous metropolis is Manhattan (Figs. 96 and 97).

New York City owes its location to a variety of factors. The Dutch at an early date recognized the strategic value of Manhattan Island, commanding the outlet of the easiest route of travel across the Appa-

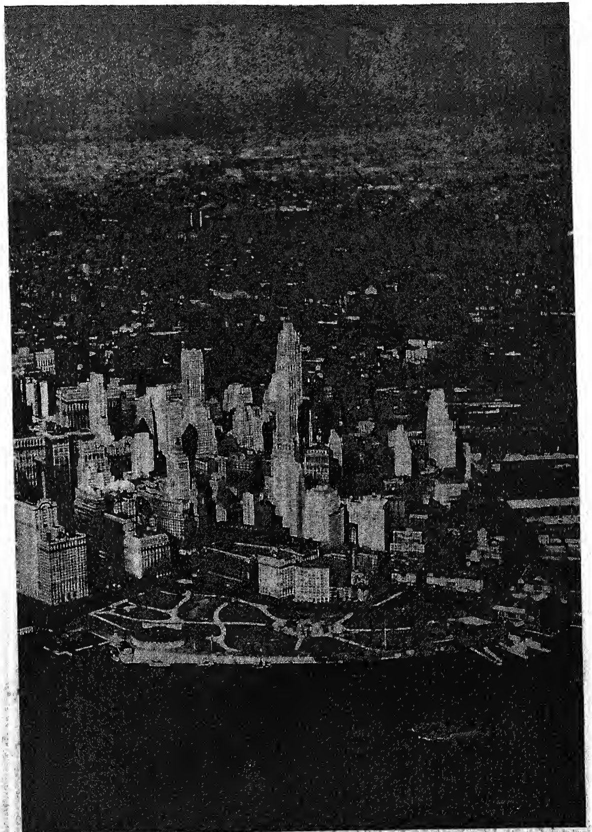

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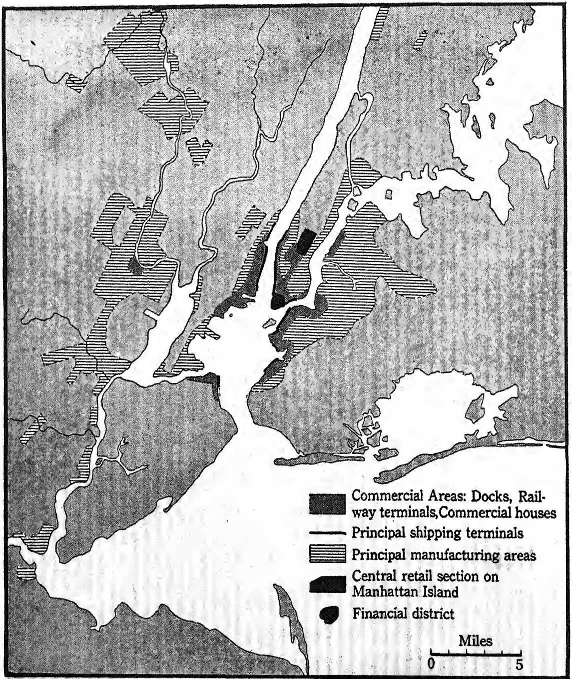
Fig. 96. *The financial district, lower Manhattan*



Map from Colby-Foster

FIG. 97. *The metropolitan area of New York*

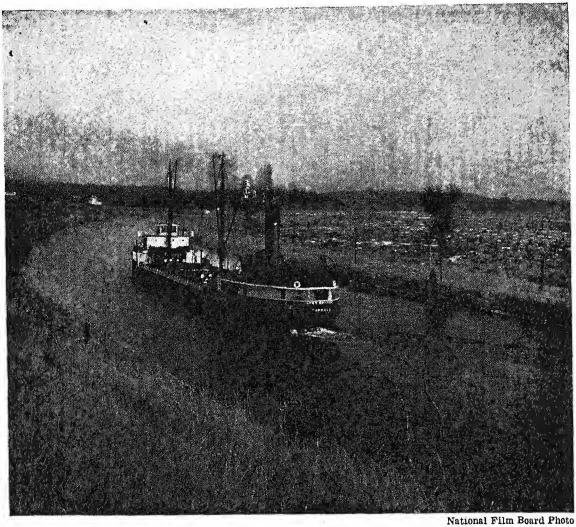
lachians. Warfare restricted the value of this route until after 1812, and its full value was not realized until after 1825. The development of New York's connections to the Middle West took place just at the beginning of the period of great expansion westward. Then, also, few great cities are built on sites which possess such natural advantages. The Hudson River is wide and deep; Manhattan Island and the near-by

shores of Long Island and New Jersey are firm and rocky. The East River and the Hudson meet in the Upper Bay, which is large enough to accommodate a vast amount of shipping. The Port of New York has a water frontage of some 770 miles, not all of which is yet developed. But all these advantages could scarcely have resulted in the growth of so large a metropolis were it not for the location of New York with reference to Europe. The exchange of people, goods, and ideas with Europe is a fundamental fact of American life, and New York is as much a reflection of these currents of exchange as it is of local advantages. Nor could New York have appeared at all except for the rise of the industrial society, with all the attitudes, objectives, and technical skills implied by that term.

Canadian Settlement in Group IV. The mid-latitude mixed forest lands of North America are not without national boundaries. Along the northern border of Group IV is Canada, separated from the United States along the "unguarded frontier" which separates two friendly and co-operative peoples. The national territory of Canada stretches far to the north into the regions of Groups VI and VII, and westward into the grasslands of Group V. But most of the Canadian people are concentrated in two separated areas close to the border of the United States, one east of the Great Lakes and the other to the west of them (Plate 1).

Canada, moreover, is strongly divided between two diverse groups. There are the English-speaking Canadians, who are predominant in the country westward from Montreal and in Nova Scotia; and there are the French-speaking Canadians, who form the majority of the inhabitants in Quebec. The attitudes and interests of the two groups are not always easy to reconcile.

Most of eastern Canada is too far north for grain-farming. The chief use of the land is for hay and dairy products. In the narrow bit of land between Lake Ontario and Lake Erie is Canada's major fruit-raising area. Toward the north the shortness of the growing season, as well as the poverty of the glacial soil, greatly restricts the significance of agriculture. In Nova Scotia, where the proximity of the ocean tempers the length and severity of the winters, apple orchards are of importance.



National Film Board Photo

FIG. 98. *Part of the "unguarded frontier" which separates Canada and the United States*

Canada has no primate city. Montreal, with a population of more than a million, is the largest city, and it owes this pre-eminence to its location at the head of navigation for ocean steamers on the St. Lawrence River. Toronto, on Lake Ontario, is only a little smaller than Montreal. Both cities are important commercial centers, and in both there is a considerable development of manufacturing industries. Manufacturing enterprises are hampered by the small size of the Canadian market and by the restrictions which keep Canadian products from reaching the markets of the United States. There are important mining and refining industries, especially in the nickel and platinum area around Sudbury; there are many scattered mills producing paper pulp from Canada's forests; and there are heavy industries manufacturing

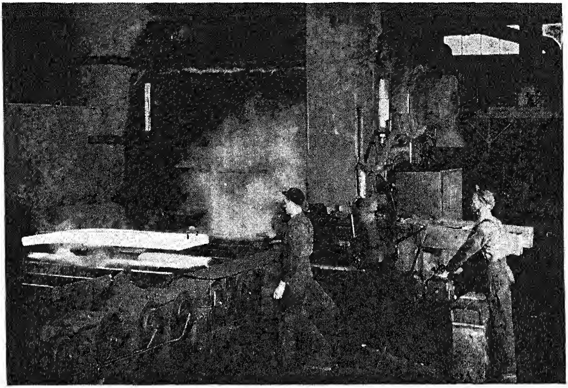


FIG. 99. *Making steel plates for ships in a Canadian rolling mill*

iron and steel products at several places along the lake fronts. The lack of one great metropolitan center in Canada may be owing in part to the geographic pattern of commerce and industry, which does not point toward the development of one central focus of the domestic economy, or it may be owing in part to the attitude of Canadians toward London, England, which perhaps functions as primate city for the whole British Commonwealth of Nations.

Group IV Regions of Western North America. From a climatic point of view, the part of North America which is most nearly comparable to western Europe is the west coast north of 40°. In North America this part of Group IV has not developed on the scale suggested by the patterns on the generalized continent (Fig. 51) because of the presence of high mountains running parallel to the coast. In British Columbia, except for a narrow bit of lowland around Vancouver, the mountains rise from the water's edge (Plate 9). In Washington and Oregon hills or mountains border the ocean; but between the coastal mountains and the Cascade Mountains farther inland there

are the Puget Sound Lowland and the Willamette Valley, in which most of the people are concentrated. The whole region is but thinly populated, and much of it is still in the stage of the first exploitation of the most easily utilized resources. Seattle is a port with connections across the Pacific to the Orient and northward to Alaska. If Alaska were to be the scene of a major movement of new settlement, Seattle would be the chief base and would provide the chief market for Alaskan products. But Alaska, also, is still in the pioneer stage. The chief commercial and industrial activities of Seattle have to do with fish and timber.

THE SOUTHERN HEMISPHERE

Mid-latitude mixed forests occur only in small areas in the Southern Hemisphere. There are five separate regions to describe: the southern part of Chile; South Brazil; the Durban area of South Africa; southeast Australia; and New Zealand.

Southern Chile. Southern Chile is very much like the northwestern part of the United States and British Columbia. The climatic similarity is reinforced by a remarkable similarity in the arrangement of the surface features. The heavy forests of rainy southern Chile begin abruptly along the Río Bío-Bío, inland from Concepción (Fig. 39 and Plate 11). To the north, in the mediterranean part of Middle Chile, are the open scrub forests and maquis, the irrigated fields bordered by roads which are dusty in the dry summers. To the south is a land of dense forests in which pioneer settlers have opened clearings in places where rainfall is not too heavy or where the wet ground can be drained. The Spaniards, who were more at home in open country than in the forests, did little more than establish a few ports south of the Bío-Bío; but the southern region was opened to pioneer settlement after 1850, when a colony of Germans was located a little north of Puerto Montt. Since that time a steady movement of new settlers from Middle Chile has moved to the new frontier, where the land is used for wheat and cattle, and the forest is utilized for its lumber. But beyond Puerto Montt and Valdivia the much embayed coast of South Chile, like the coast of British Columbia and Alaska, offers little opportunity for settlement

where the rainy mountain slopes come to the edge of the sea. Puerto Montt occupies a position in many respects similar to that of Seattle; but south of Puerto Montt there is no Alaska, and to the west there is only a vast ocean.

South Brazil. South Brazil is the region which lies in the lower middle latitudes of eastern South America, south of the coffee region of São Paulo. Its climate, its mixed broadleaf and conifer forest, its hilly dissected plateau surface, all combine to form a strong resemblance, so far as physical conditions are concerned, to the southern part of the Cumberland Plateau in Alabama. This part of Brazil was not all divided into large estates by the early Portuguese settlers, because these people, like the Spaniards, avoided the heavy forests in favor of the open grasslands. The forests of South Brazil were first occupied during the nineteenth century by colonies of Germans, who established a pattern of small farms in woodland clearings. Later pioneer settlers have included Italians, Poles, and others, as well as Brazilians from farther north. The colonies have been notably successful, and a considerable pioneer expansion has taken place around the original nuclei. No spectacular wealth has been produced in this region, but rather a sound local economy has been developed based on the sale of hogs and other farm products to small, but growing, urban markets. This is one of the world's largest areas of land suitable for pioneer farm settlement to which immigrants might still come.

South Africa. Very little of South Africa belongs in Group IV. There is a narrow fringe of mid-latitude forest along the east coast north of the mediterranean region. Along most of this part of the coast the lower hilly slopes of the escarpment descend to the water, leaving no flat coastal plain for agricultural development (Plate 13 and Fig. 12). The chief town of the area is Durban, a port which acts as the commercial center for the settlements in the interior and along the coast farther north. It is a naval base of importance.

Australia. The most important of the Southern Hemisphere regions of Group IV is in southeastern Australia. The mid-latitude mixed forest region extends from north of Brisbane to the southeast coast

Commonwealth Government Photo

FIG. 100. *Millions of sheep graze in Australia on land that is too dry for crops*

around Melbourne and to the island of Tasmania. Most of the area is hilly, and northeast of Melbourne the hilly lands are surmounted by the high Australian Alps (Plate 19 and Fig. 50). There are only a few narrow lowlands such as those around Melbourne and Sydney. Wheat farming is concentrated in the eastern part of the Great Plains west of the hilly uplands, where the Murray River and the Darling River flow westward toward the dry interior. The extension of farming westward is restricted by the low and uncertain rainfall; the increase of farm land in the humid east is restricted by the hilly nature of the terrain. In the south, around the city of Melbourne and on the island of Tasmania, the land is used for the pasture of large numbers of sheep (Fig. 100).

Like Canada, Australia has no primate city. Both Sydney and Melbourne have more than a million inhabitants. At Sydney, and north of it along the coast, there are numerous industrial establishments based on local sources of coal. But Australia, also, looks to London as the major commercial and cultural center of the British Commonwealth.

Australia as a whole is very thinly populated. It is hoped to raise the total number of people from 7,000,000 (1946) to something like 22,000,000, chiefly by bringing immigrants from Great Britain. Although the British can scarcely spare such a large number of their young and most productive people, a considerable current of migration to the dominions is likely to develop during the next decade. Australia's territory is mostly too dry for very dense settlement; the larger proportion of the immigrants will be settled on farms in the southeast, greatly increasing the density in this region, and thereby strengthening the whole Australian economy.

New Zealand. New Zealand is mostly mountainous (Plate 19). Its chief areas of settlement are located on the relatively small lowlands around Auckland, Wellington, and Christchurch. Although some wheat is raised around Christchurch, the chief use of the land on South Island is for the pasture of sheep. North Island, which enjoys a somewhat milder climate, has a larger area of good farm land and pastures suitable for cattle. Like Canada and Australia, New Zealand has no primate city. New Zealand, also, is looking for immigrants from Great Britain, and is especially anxious to establish new manufacturing industries to process the raw materials originating on farm and ranch.

Conclusion

The mid-latitude mixed forest lands are occupied by nearly two fifths of the world's population. There are regions within this group with very dense populations; and there are other regions still available for more pioneer settlement. There are populations which have gone through a period of rapid increase during the past century, and are now again approaching an almost static or, perhaps, even a declining condition; there are other populations still growing rapidly; and there are some which stand on the verge of a great era of expansion. In the Orient there are major problems to be solved of the relation of people to the resources of the land—of the means of increasing the supply of food, clothing, and shelter. But in the Occidental world the technical knowl-

edge exists to provide a much better level of living than now prevails: in these countries the major problems to be solved are those of adjusting the institutions and habits of thought inherited from the era of horses and sailing ships to the realities of the industrial age.

But the industrial society cannot be understood against the background of any one of the world's groups of regions. That the chief centers of industry and commerce are in the regions of Group IV is the result of a variety of factors, and the present economic and political pre-eminence of these regions can scarcely be understood without reference to the rest of the world. The industrial society has been evolved in an atmosphere of expansion: the population itself was growing at a rapid rate, and this was providing always larger and larger markets. Pioneer settlers were also moving into new regions, and bringing into economic use a wide variety and enormous quantity of new products. There was wide opportunity for individual initiative and profit. And the greatest profits went to the people who had first developed the new technologies—to the people of the English-speaking world.

A very important part of the process of expansion took place not in the regions of Group IV, but in other parts of the world not previously exploited. This outward movement into new lands brought the Occidental people into contact with many other cultures, and the contact was usually disastrous for the other people. We have seen some of the results of Occidental contacts in the dry-land regions of the world, and in the tropical forests. But the greatest expansion was taking place in the grasslands and to a somewhat lesser extent northward in the Northern Hemisphere. We now turn our attention to these other groups of regions in the world and to the penetration of them by Occidentals. When we have completed our survey of these peripheral areas, we shall return to a discussion of the industrial society as a world phenomenon.

GROUP V

THE GRASSLANDS

Some 21 per cent of the earth's land surface has a natural vegetation cover of grass. In position these grasslands are intermediate between the forests and the deserts. They are distinguished from the former by the prevailing scarcity of trees, and from the latter by a relatively continuous cover of vegetation. However, while these distinctions appear to be clear-cut when viewed on a world scale, an examination of the group boundaries in greater detail reveals broad zones of transition between grasslands and forests on the one hand, and between grasslands and areas of scattered xerophytic shrubs on the other.

If the grasslands occupy an intermediate position among the great natural divisions of the earth, they are nevertheless distinctly marginal with reference to the centers of population. As we have already seen, a large proportion of the earth's human inhabitants occupy the mixed forests of middle latitudes and the light semideciduous forests of the Asiatic low latitudes. Recently, settlement has pushed out from these forests onto the contiguous grasslands, so that now parts of Group V share with the mixed forest lands those spectacular developments of the machine culture which we have just described. In fact, it is from the more accessible grasslands that the major portion of the grain and meat supply for the support of the great urban populations is now derived. Where the grasslands have been subject to agricultural settlement a transformation of the primitive landscape no less remarkable than that of the forest clearings has taken place. The present distribution of such settlements illustrates once again the vital role played by culture in the establishment of geographic limits.

The Land

VEGETATION AND CLIMATE

Because the grasslands are intermediate in position between the deserts and the forests, the landscapes developed in the various parts of this group represent a series of transitional types between the border-

ing groups. The gradual change from abundant moisture to aridity, through zones which are sometimes characterized as subhumid and semiarid, is reflected in the character of the vegetation. Three chief types of grassland are commonly recognized. In the middle latitudes the dry margins of Group V are occupied by the *steppes* and the wet margins by the *prairies*. In the low latitudes several kinds of *savannas* reflect the transition from forest margin to desert margin. We shall consider each of these in turn.

The Steppes. The change from the xerophytic shrub vegetation of Group I to the steppe grasses of the cool, semiarid portions of Group V brings a notable difference in the landscape. The actual boundary between the two is not everywhere easy to identify when it is sought in topographic detail, although in some parts of the world the limits are sharp enough for this. Generally speaking, the vegetation of the dry lands fails to form a complete cover over the surface of the land; if grass is present, as in the "desert shrub-desert grass" formation, it grows in bunches with bare ground between the plants. The steppes, on the contrary, are covered with a nearly continuous mat. At maturity the steppe grasses are only a few inches in height, although in unusually wet years taller grasses give the vegetation cover an uneven appearance. Normally the steppes resemble a closely pastured meadow,—a landscape of striking monotony which extends unbroken to the horizon.

The short grasses of these regions are developed in areas deficient in moisture. Like the xerophytic shrubs of the deserts, these plants are adapted to long periods of drought. After a rain they spring quickly into activity, completing the life cycle within a short time and then remaining parched and brownish until the next shower brings renewed life. The water is absorbed by the surface layers of the soil, but very rarely is enough received to penetrate to the water table. Soil moisture is available to the grass roots near the surface for a period after a rain, but underneath this surface layer there is a zone of permanently dry soil. Deep underground, as in the deserts, lies the zone of saturation, replenished at rare intervals by unusual rains. It is the presence of soil moisture near the surface that makes possible the growth of the shallow-rooted short grasses.

FIG. 101. *An encampment on the Kirghiz Steppe*

In general, the steppes are associated with a semiarid type of climate (Plates 10–20 and 8). However, this relationship is obscured in many places; for the grasslands, which, on the generalized continent (Fig. 51) almost completely surround the deserts, are much interrupted by mountains. The mid-latitude margins of the great dry-land area of North Africa and Eurasia are actually bordered by steppes in only a few places: in the northern interior, extending from the western side of the Black Sea eastward beyond Lake Balkhash, including the great Kirghiz Steppe; two small patches in the Far East, in Manchuria and the Ordos Desert; and in North Africa, where there is room for only a narrow band of steppe between the desert and the mountains or the Mediterranean shore (Plate 14).

In the other parts of the world similar irregularities may be observed. In North America the steppes are developed only on the east and north of the dry lands. The Great Plains extend from Texas into

southern Canada, and a small steppe area in Washington and Oregon borders the northern limits of the dry lands of the intermontane plateaus and basins. In South America the steppes, like the deserts themselves, are much distorted by the Andes. Along the eastern piedmont of the mountains in Patagonia there is a narrow zone of steppe which widens southward toward the Strait of Magellan. The tall bunch grasses of the Argentine Humid Pampa, which lies east of the desert, are mixed with a dwarf scrub forest known as *monte* along the dry margin, and there is no zone of short-grass steppe between the prairies and the dry lands. Nor is there a steppe bordering the dry-land region of South Africa. In Australia the steppe is limited to the eastern desert border in the basins of the Murray River and the Darling River.

Even in regions where the steppe does form a zone of transition between the arid climates of the desert and the subhumid climates of the wetter lands, the relations to the climatic lines are not always simple. In the classification of climates developed by Wladimir Köppen a formula was devised by which arid, semiarid, and humid climates might be distinguished on the basis of average monthly and annual figures for temperature and rainfall. This formula is presented in Appendix B, section 30. The climates are described by letter: an arid climate is represented by the letters *BW*; a semiarid climate by the letters *BS*. The distribution of climates according to the Köppen system is shown on Plate 8.

A comparison of the outlines of the *BS* and *BW* climates with the observed distribution of vegetation shows a number of important differences of pattern. In many places xerophytic shrub vegetation is found well beyond the area of *BW* climate—as in western China or the western interior of the United States. As a matter of fact, in nearly all the vegetation distributions thus far described, forest as well as desert, numerous departures from the generally related climatic patterns can be observed. These have been interpreted, in part, by reference to edaphic or other nonclimatic factors. Edaphic factors, however, do not seem adequate to explain such extensive departures from the climatic pattern as those of the desert-steppe boundary.

Another interpretation of the desert-steppe distribution recognizes the importance of the extreme years as opposed to average years in estab-

lishing vegetation limits. Variability in the amount of rainfall received from year to year is at a maximum in the deserts. There are parts of the regions of *BW* climate in which the rainfall may differ in any one year as much as 40 per cent from the average. But the dry lands are normally deficient in moisture, and torrential rains are unusual, although spectacular, occurrences. The semiarid grasslands bordering the deserts also show a marked rainfall variability from year to year; but because the grasslands are on the margin between sufficient and deficient moisture, the rainfall fluctuations are much more critical than they are in the deserts. In the grasslands a succession of wetter years is inevitably followed by a period of dry years. The *B* boundary, that is, the boundary determined by Köppen's formula between the semiarid *BS* climates and the bordering humid climates, has an average position which is shown on Plate 8; but it shifts widely from this average position when it is plotted for individual years. In fact, rarely does the actual border between sufficient moisture and deficient moisture in any one year lie close to, or even correspond in trend with, the average *B* boundary. This condition is illustrated by a map of this critical boundary in the United States in a succession of years. During the period from 1915 to 1924, humid years were experienced as far west as the front of the Rocky Mountains, and dry years were experienced as far east as Minnesota (Fig. 102).[1] Russell suggests the possibility that the recurrence of a very dry year (a *BW* year) at not infrequent intervals may serve more effectively to limit the spread of grasslands toward the deserts than does the average condition (Fig. 103).[2]

The Prairies. The prairies are quite distinct from the vegetation types which border them. Unlike the grasses of the steppes, the prairie grasses are tall and deep-rooted. At maturity they reach heights of from three to more than ten feet. The natural grasses of the Argentine Pampa are said to have risen above the head of a man on horseback. Few scenes in the New World so impressed the early travelers from

[1] H. M. Kendall, "Notes on Climatic Boundaries in the Eastern United States," *Geographical Review*, Vol. 25 (1935), pp. 117–124.

[2] R. J. Russell, "Dry Climates of the United States, II, Frequency of Dry and Desert Years, 1901–1920," University of California Publications in Geography, Vol. 5, No. 5 (1932), pp. 245–274.

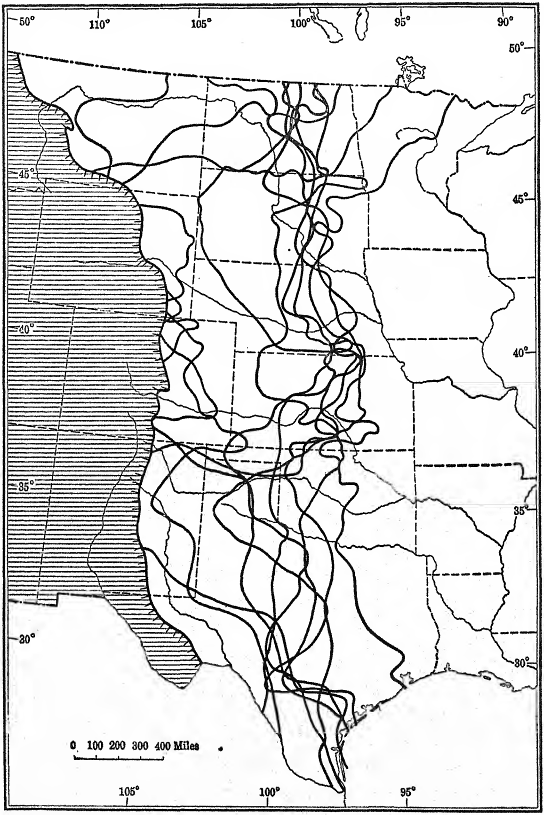


FIG. 102. *Fluctuations of the semiarid/humid boundary in the central part of the United States, 1915–1924.* (After Henry M. Kendall)

Europe as did the sight of the great expanses of grass billowing in the wind. Around most of these prairies the edge of the forest is sharply defined. Except for the galeria forests along the streams, the prairies themselves, in their natural condition, remain entirely treeless.

Toward the steppes the prairies are limited by a fairly definite moisture supply. Where the zone of moist soil extends for as much as two feet below the surface, the tall grasses are able to gain a foothold at the expense of the short grasses. Russell finds that in the United States this condition, and with it the prairie-steppe boundary, corresponds closely to the eastern limit of the area which receives at least one very dry (*BW*) year in twenty (Fig. 103). In topographic detail this prairie-steppe boundary is much influenced by edaphic conditions. On sandy soil the depth of the moist surface layer is greater, climatic conditions being equal, than on clay soil. Therefore the tall grasses penetrate well within the areas generally deficient in moisture on sandy soils, but short steppe grasses are found on clay soils well within the humid lands.

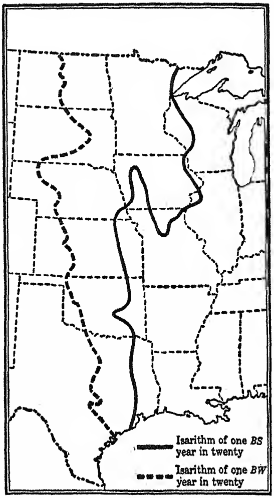


Fig. 103. *Freqency of semiarid (BS) and arid (BW) years in central United States.* (After Richard J. Russell)

The boundary of the forest and the prairie has been the subject of much controversy. Trees can apparently gain a start where the moisture is sufficiently abundant so that no permanently dry zone exists below the moist surface horizon of the soil. On the dry side of the prairie, even where the moisture penetrates more than two feet, a permanently dry zone exists below. With a somewhat more adequate moisture supply, however, more water is received than can be held in

the surface layers, so that moisture penetrates, at least at frequent intervals, to the ground-water table. This, in many parts of the world, marks the forest-grassland boundary. But in other places the prairie extends well within such humid lands; for example, in the Middle West of the United States, or in the northeastern parts of the Argentine Humid Pampa, Uruguay, and southern Brazil, or in the plains of Hungary. A number of interpretations of this fact have been set forth. Russell shows that the prairies of Illinois correspond to the outline of the area with at least one dry year (*BS*) in twenty (Fig. 103). Other writers have pointed out that the tall grass of the prairies is easily set on fire, especially if the autumns are dry, as they are in most of these prairie lands. Fires may be started by the inhabitants, or even without human aid, by lightning. The intense heat kills the young trees which otherwise might gain a foothold on the prairies, in the course of time perhaps pushing back the forest margin.

The Savannas. In the low latitudes a wide zone in which forests and grasslands are intermingled occupies the drier parts of the humid climates and crosses the *B* border to the margins of the deserts. This is the zone of the savannas. Essentially this is a transition between forest and desert, but the landscapes which are developed differ in important respects from those of the mid-latitude transitional grasslands. Not only are the savannas ribbed with galeria forests along the streams, as are also the prairies and some of the steppes, but the savanna flora includes enough scattered trees so that in only a few places is the horizon visible. The tropical scrub forests merge almost imperceptibly with the savannas. In some parts of the world the scrub forests actually border the xerophytic shrub of the dry lands without any intervening zone of savannas.

The savannas themselves can be divided into a succession of types reflecting the transition from wet to dry. These different kinds of savannas can be illustrated by a study of the Sudan of Africa (Fig. 104).[1] In the south, bordering the selva of the Congo, lies the "high grass–low tree savanna," composed of grasses which, at maturity, reach

[1] H. L. Shantz and C. F. Marbut, "The Vegetation and Soils of Africa," American Geographical Society, Research Series No. 13, New York, 1923.

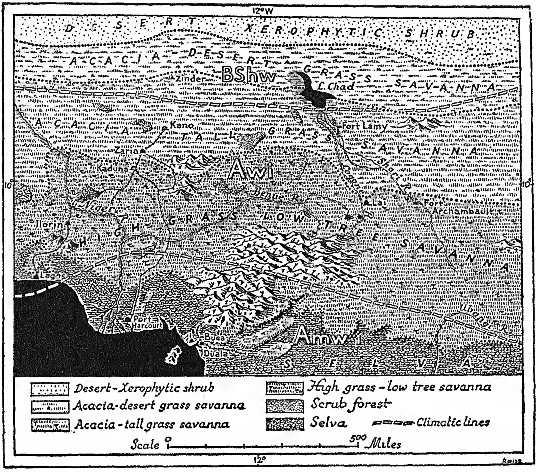
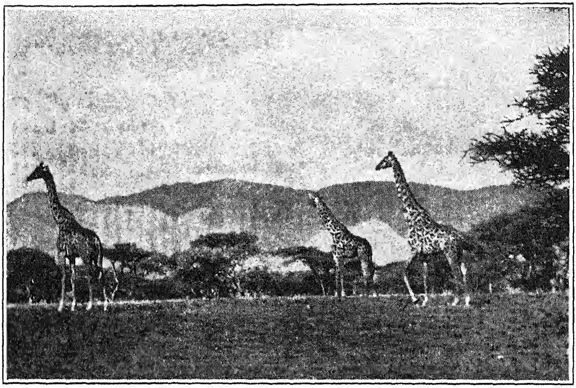


Fig. 104. *The savannas of the Central Sudan.* (Vegetation after Shantz and Marbut)

heights of ten or twelve feet, mixed with a fairly close scattering of low trees, together with numerous patches of thicket. The grasses are coarse and do not form a sod, because each plant stands individually. Farther north, in the direction of decreasing rainfall, this formation gives way to the "acacia–tall grass savanna," composed of grasses growing from three to five feet in height and associated with scattered, flat-topped acacias which stand somewhat farther apart than the low trees of the southernmost zone. Still farther north, extending across the *B* boundary, is the "acacia–desert grass savanna," where the stunted trees stand far apart and the short desert grasses cover most of the surface. Thus representatives of the forest extend all the way to the edges of the desert, while, as we have seen elsewhere, patches of open savanna are found in the midst of the selva. Similar transitional types are found in other parts of the world.



Three Lions

FIG. 105. *Giraffes on an African savanna*

Information regarding the relationship of the savannas to climatic conditions is difficult to obtain. Climatic stations in the savannas are widely scattered, and their records are mostly fragmentary. Certain it is, however, that few parts of Group V suffer such extreme fluctuations of rainfall from year to year or such extreme variations from season to season as do the savannas. Almost every year in the Sudan is abnormal in regard to either rainfall or drought. No doubt more adequate data would suggest the importance of the extremely dry years in establishing the margins of the savanna and the tropical forests (Fig. 105).

No other parts of the low latitudes exhibit such a marked change in their appearance with the march of the seasons as do these tropical grasslands. During the dry season the coarse grasses become parched and brown, and the scattered trees lose their leaves and stand with bare limbs. The beginning of the rainy season witnesses a most remarkable awakening of the plants; the trees quickly send out a covering of new leaves, while the tender young shoots of grass give the ground a carpet of velvety green.

SURFACE FEATURES AND DRAINAGE

Most of the grasslands are developed on relatively level surfaces,—either plains or plateaus. Although in some cases these lands may be gently rolling, only rarely can they be classified as hilly. Most of the hilly areas which interrupt the grasslands receive more plentiful rainfall than the surrounding plains, and are forest-covered.

On the vast level surfaces of the grasslands the transitional character of the rainfall is faithfully reflected in the drainage features. The rivers, especially in the savannas, have a marked seasonal rise and fall. During the dry season they slowly lose volume, in part by the loss of tributaries which dry up, in part by evaporation. As they lose volume and velocity they drop a large part of their load, and this accumulates in the river channels, forming a maze of sand bars. When a river is choked with its alluvium, it may split apart into many small rivulets, producing a typical braided channel. Near the arid boundary, if the river is flowing toward the desert, this accumulation becomes so great that the river tends to spread out and form an extensive shallow marsh. All three of the rivers of northern Africa which cross the savannas toward the Sahara behave in this way. The rivers in a semiarid climate, being exotic, receive few tributaries, for no local streams can rise within the regions of deficient moisture.

The seasonal contrast is especially great in the savannas. The glistening white sand banks of the streams are speedily submerged when the rainy season begins. Unlike the rivers in the forest lands, these streams are so clogged with silt that the waters cannot easily drain off, and therefore vast areas of lowland may be inundated. From brown, parched drought to widespread flood is a seasonal change which rivals the snowy winters and verdant summers of the higher middle latitudes.

Especially in the savannas, the effect of these seasonal drainage contrasts is determined in large part by the type of country. Where the rivers lie close to the surface, as on the Shari Plain or on the "llanos" of the Orinoco, the rainy-season floods cover a vast extent of territory. In contrast, where the streams are incised in youthful or mature valleys in a plateau, as in the plateau of Brazil or of South Africa, the floods

Thomas F. Lee from Ewing Galloway, N. Y.

FIG. 106. *Cattle grazing on the llanos of the Orinoco. Galeria forest in background*

are confined to the immediate valleys. While the first type of country may suffer from rainy-season floods, the latter type is more exposed to dry-season droughts. The distribution of these types of surface is indicated on the accompanying maps (Plates 9–19).

SOILS

Some of the most fertile soils in the world are in the grasslands, especially the prairies. The contrast between the dark-colored prairie soils and the lighter soils of the neighboring forests of Group IV is very great. In order to understand the pre-eminence of the grassland soils we must turn briefly to a review of the soil-making processes.

A Review of the Soil Processes. The development of a regolith is the first step in the construction of a soil. Under the influence of the atmosphere the process of weathering results in the disintegration and decomposition of the exposed rock material at the earth's surface. To be sure, the character of the climate affects the nature of this weather-

ing process; for chemical decomposition, producing a fine-textured regolith, is emphasized in hot and moist climates, while physical disintegration, producing a relatively coarse regolith, is emphasized in dry climates, especially those with a temperature range which crosses the freezing point. But the differences of texture and composition of regolith in any climate are closely related to the nature of the parent material. The geologic map furnishes the pattern for the map of regolith.

The production of a soil on the surface of the regolith is the result of three processes. The percolation of water through the surface layers on its way down to the water table is responsible for the first two of these: leaching and eluviation (pp. 91–92). Leaching, like all other chemical processes, is at a maximum in hot and rainy climates; eluviation also goes on most rapidly where an abundance of water is moving down through the regolith. Both leaching and eluviation cease where there is no percolation of water, whether this is due to a desert condition, to a permanently waterlogged condition as in a swamp, or to a permanently frozen condition as in the polar regions. These processes are only retarded, of course, in places where droughts, floods, or frosts recur seasonally. Under any given type of climate, however, both leaching and eluviation proceed much more rapidly where the regolith is coarse in texture than where it is fine and compact.

The third soil-making process is the accumulation of humus. This goes on most rapidly not only where the largest amount of organic litter is provided by the vegetation but also where the destruction of this litter by bacteria is not too rapid. Bacterial action is at a maximum in hot, moist climates, and declines with lower temperatures or decreased moisture. Although the tropical forests supply a considerable amount of litter in the form of dead leaves and twigs, the bacteria, together with the destructive activity of ants and other small animals, quickly destroy this material. The rate of humus accumulation in the forest lands increases as one proceeds toward cooler climates. Whereas the tropical forest soils as well as those of the lower middle latitudes are characteristically light-colored, those of the higher middle latitudes (north of Chesapeake Bay in eastern North America) are somewhat darker in color. No forest vegetation, however, can supply such an

abundance of organic material as can a grass cover, with its yearly increment of dead stems and its mat of fine roots. The grassland soils are black or dark brown in color.

As these soil-making processes continue they produce a gradual change on the surface layers of the regolith. In the course of time three horizons become more and more clearly distinguished. The surface, or *A horizon,* is one which has felt the maximum of leaching, has been rendered somewhat coarser in texture than the original regolith by the process of eluviation, and has been mixed with whatever amounts of humus are available. The *B horizon* is a zone of accumulation, rendered finer in texture than the original material by the addition of the fine particles brought down from above. Underneath is the *C horizon,* the unleached and uneluviated parent material. The depth and character of these horizons reflect the balance of the soil-making processes as controlled by the climate and the cover of vegetation. Not until the first signs of these horizons appear, however, is the regolith said to have a cover of soil. As the horizons become more and more clearly defined the soil is said to become mature. Theoretically, given a long enough time, the soils lose the characteristics imparted to them by the underlying parent material, and throughout the broad regions of similar climate and vegetation cover the mature soils all take on the same kind of profile. The patterns of soil distribution which are related to the underlying geology are gradually obscured by the broader patterns related to the climate.

Mature soils, however, can only develop where the regolith is undisturbed. On steep slopes where creep or flow is active the A and B horizons are stripped off as fast as they are formed, and fresh regolith is brought to the surface. On river floodplains fresh alluvium is laid down before any soil horizons can be formed in the older deposits. Similarly, in areas of active loess accumulation mature soil profiles should not be expected. Mature soils can develop only on level or gently rolling surfaces free from active deposition and exposed to the soil-forming processes for a sufficiently long period of time. In hilly lands only minor portions of an area can have mature soils; nowhere but on the more level plains are any extensive areas of such soils to be found.

Grassland Soils.[1] Over the wide expanses of rolling to level plains in Group V, however, the soils are able to reach maturity and to reflect closely the transitional features of the climate. A succession of soil types, from the humid forest margins across the prairies and the steppes to the dry lands, conforms to the changes in moisture and vegetation cover. On the rainy margins of the prairie a deep soil is formed which is so abundantly supplied with organic material that it is dark-colored even in the B horizon (Fig. 107, *C*). This is the *black prairie soil.* But near the dry margin of the tall-grass prairies a very important change in the moisture conditions takes place, a change which is critical in soil formation. No longer, except at rare intervals, does enough rain fall on the ground to percolate through to the ground-water table. Whereas the black prairie soils are subject to leaching like all other humid soils, the soils on the dry margins of the prairie cannot be similarly robbed of their soluble constituents. The minerals which are dissolved near the surface are carried down to the B horizon, but no farther. The result is the accumulation of these soluble minerals in the subsoil.

Two soil types share this peculiarity of having mineral accumulations, chiefly lime, in the B horizon. The first of these, occupying the dry margins of the prairies, is known as the *chernozem* (Fig. 107, *B*). The color of the chernozem is even darker than that of the black prairie soil, and its fertility is increased by the decreased effectiveness of the leaching process. The humid boundary of the chernozem is not easy to identify, for this type grades almost imperceptibly into the black prairie soil through a zone where the small and scattered lime concretions occur only here and there in the subsoil. The dry boundary of the chernozem, on the other hand, is quite distinct. It coincides with the prairie-steppe boundary, where, because the depth of the moist

[1]See the classic treatment of the Great Plains of the United States: C. F. Marbut, "Soils of the Great Plains," *Annals of the Association of American Geographers*, Vol. 13 (1923), pp. 41–66; J. B. Kincer, "The Climate of the Great Plains as a Factor in Their Utilization," *Annals of the Association of American Geographers*, Vol. 13 (1923), pp. 67–80; H. L. Shantz, "The Natural Vegetation of the Great Plains Region," *Annals of the Association of American Geographers*, Vol. 13 (1923), pp. 81–107; O. E. Baker, "The Agriculture of the Great Plains Region," *Annals of the Association of American Geographers*, Vol. 13 (1923), pp. 109–167; see also F. Shreve, "Rainfall, Runoff and Soil Moisture under Desert Conditions," *Annals of the Association of American Geographers*, Vol. 24 (1934), pp. 131–156.

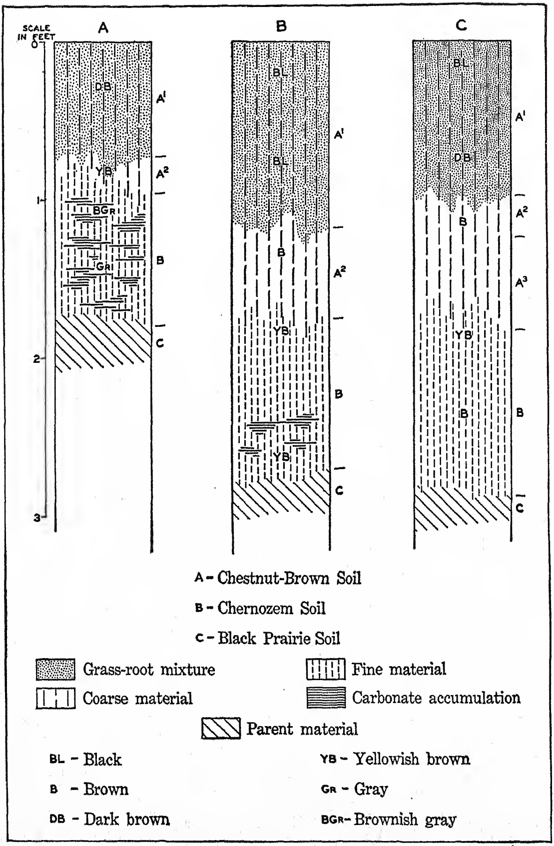


FIG. 107. *Generalized mature soil profiles developed under grasslands.* (After Jenny)

surface soil becomes less than approximately two feet, the tall grasses give way to the short grasses. The smaller supply of humus from the short grasses is reflected in a change from the black color of the chernozem to a chestnut-brown color; and the more active evaporation and shallower penetration of the rain water result in the formation of a continuous layer of lime salts much closer to the surface than in the case of the chernozem (Fig. 107, *A*). This is the *chestnut-brown soil.*

The soils of the tropical grasslands are little known.

The distribution of these soil types, where they have been adequately studied, conforms closely with the vegetation and climatic patterns. The black prairie soils are apparently rather unusual; the largest area of these, probably, is in the United States. The chernozems and chestnut-brown soils in both North America and Eurasia, where they have been carefully mapped, straddle the boundary between humid and semiarid climates.

The Occupance

The occupance of these grasslands provides numerous illustrations of the way in which different cultures have reacted differently to the same complex of physical conditions. To most primitive peoples armed with few agricultural implements the grasslands have not yielded an abundance of resources. On the other hand, nomadic peoples with domestic animals find in the open plains a favorable, although at times uncertain, habitat. The large-scale occupance of the grasslands, however, is a recent phenomenon. Various kinds of machines have in numerous ways made possible the development of the mid-latitude prairies and steppes as surplus grain-producing regions, and from these lands now comes a large part of the food supply for the Occidental urban centers. But even today the penetration of the tropical savannas by white people is uncertain and experimental.

AGRICULTURAL OCCUPANCE BY SIMPLE CULTURES

The fact that the grasslands are unattractive to primitive agriculturists is not difficult to understand. The clearing of grass presents great difficulties for workers armed with few implements. For them the

partial clearing of a forest is much easier than the removal of tall grass. On the steppes, where the short grass is less of a problem, the decrease of moisture becomes critical, especially for people who do not possess the machinery or techniques to reach dependable supplies of water.

The few cases of the establishment of sedentary agriculture on the grasslands by peoples of simple cultures are all the more remarkable because they are exceptional. The chief examples seem to have resulted from contacts with more complex cultures. For example, when the Scythian nomads of the Russian steppes so radically changed their mode of life as to become wheat farmers, it was under the influence of the Greek colonists who had established themselves on the northern shore of the Black Sea.[1] Yet from this region came the greater part of the grain supply for the support of ancient Athens—an extraordinary preview of the type of occupance which, some twenty-five centuries later, is dominating this and analogous regions.

The Negro tribes of the African Sudan have also established a sedentary agricultural occupance on the savannas. Although the moderately dense populations (Plate 3) of Nigeria and the French Sudan have been built up rather recently, still, long before the European conquest, agriculture was well established in parts of this region. To what extent the cultural traits of these tribes (including the smelting of iron, the making of iron tools, and an excellent dry-farming technique) had been introduced by the Arabs, and to what extent these things really are native to the Negro cultures, is not known. The subsistence agriculture in these regions is based on rice, grain sorghums, millet, maize, peanuts, and a number of other crops (Fig. 108).

THE NOMADIC OCCUPANCE

While most of the world's grasslands have not favored agricultural settlement by simple cultures, those peoples who possess domestic animals have been able to gain at least a precarious existence. But before the spread of the Europeans, knowledge of domestic animals was limited to only one of the world's great areas of grassland. It is a remarkable fact that of the thirty animal species which are of chief importance

[1]E. C. Semple, *Geography of the Mediterranean Region* (New York, 1931), p. 357.

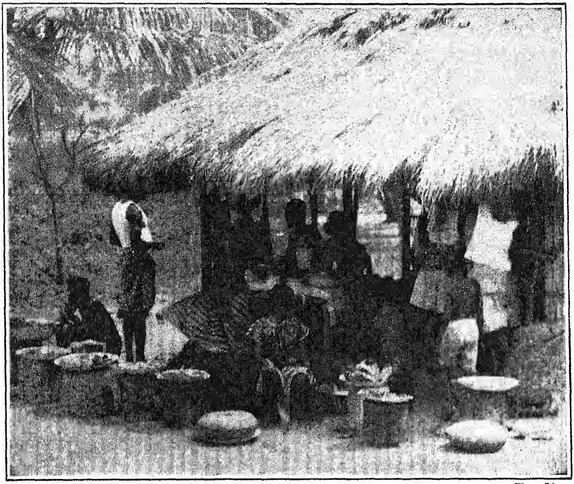


FIG. 108. *Natives of the African Sudan have fruit and vegetables for sale at the bazaar*

to mankind, all had been domesticated before the dawn of written history, and all but four originated in eastern, southern, or central Asia and in the neighboring regions of Europe and Africa. Except for the ubiquitous dog, the only animals of importance which were domesticated outside these parts of the world were the reindeer of the polar regions of Eurasia and the llama of the Peruvian Andes (Fig. 109).[1] Only on the grasslands of the Old World—those of North Africa and Eurasia—is a non-European nomadic occupance based on domestic animals to be found, and even in these regions this type of life is rapidly disappearing as the range of movement of the nomads becomes more and more restricted. The Soviet Union has largely eliminated nomadism from the Asiatic steppes and from Outer Mongolia by establishing

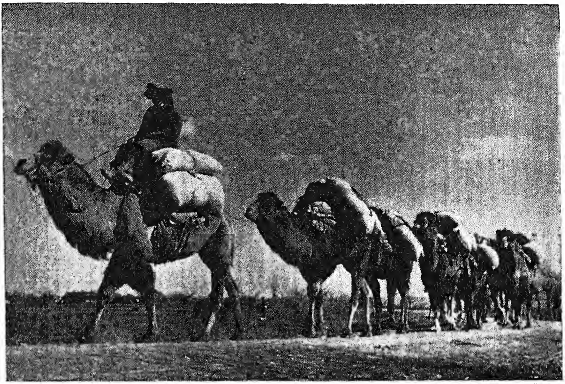
[1]Ellsworth Huntington, "The Distribution of Domestic Animals," *Economic Geography*, Vol. 1 (1925), pp. 143–172.

Severin from Three Lions

FIG. 109. *A boy and his llama on the shore of Lake Titicaca*

fixed settlements for the pastoral peoples. Where nomadism is still found, sheep and goats are of primary importance, although cattle predominate in a few especially favored localities. Horses and camels also play a vital role in the nomadic life. We have already described the effect on the Berbers and Arabs of the importation of the dromedary, without which ally their conquest of most of northern Africa would have been impossible.

The word "nomad" implies the absence of a fixed location. Nomadic peoples are free from the close attachment to the earth which of necessity characterizes the agriculturists. To be sure, certain of the forest dwellers, carrying on migratory agriculture, establish only temporary attachments to the land which are periodically broken; and other peoples, making use of the resources of contiguous regions, may make more or less regular seasonal migrations from one locality to another.



Sovfoto

FIG. 110. *Merchandise being transported by camels in Sinkiang*

Such peoples may be termed *seminomadic.* But the true nomad at no time thinks of his encampment as in any sense fixed; and even if the passage of the seasons finds a nomadic tribe moving regularly back and forth between neighboring areas, as between a mountainous region and the plains close by, the routes of travel are seldom the same, except, perhaps, where a mountain range enforces the use of a certain pass, or where the crossing of a large stream is possible at only one point. A map of the distribution of nomadic peoples would show always the same pattern of scattered groups, but the position of the groups would be ever-shifting.

The nature of the nomadic occupance enforces this freedom. The wealth of the nomad is represented solely by the number and condition of his animals. He has no other possessions that he cannot quickly pack and move on the backs of his horses or camels. From his flocks and herds he gets the material for his clothing, his house, his rugs, and his implements; from them he gets his meat and milk; from them he derives a surplus to exchange with the sedentary agriculturists for grain, dates, tea, or other agricultural products; and it is on his animals that he

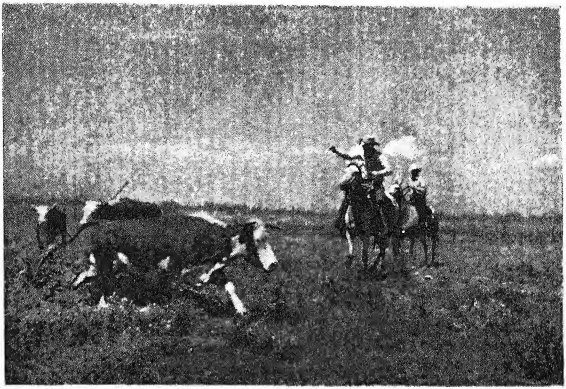
relies for the mobility which is an essential part of his life. In these lands of uncertain rains the pasturage is dependent on the scattered showers. When the nomad hears of a rain, he must be ready quickly to move his animals into the section which has been moistened, in order to take advantage of the brief period of rich growth which will follow. Rainy years to these people mean years of plenty, even of luxury.

Not uncommonly, nomadic peoples take advantage of complementary regions. The people of the Kirghiz Steppe, for instance, move their flocks into the high plateaus of the Altai Mountains during the summer, returning to the grasslands for the winter. Many of the nomadic peoples of the Sahara, who claim ownership of the various oases, enter the deserts only during the winter, leaving them either for the high pastures of the Atlas Mountains or for the savannas south of the desert during the summer months.

In comparison with their numbers, the steppe nomads have wielded a very great political power. For various reasons they have since time immemorial established their control over the neighboring sedentary agriculturists. These two contrasted groups of people, so necessary to each other, are traditional enemies. The nomad, because of his military organization and his mobility, is usually the conqueror; but the agriculturist, because of his permanence and the strength of his attachment to the land, has always survived and at last absorbed his conquerors.

The recurring cycles of dry years, which are so characteristic a feature of the steppe climate, have played a very important part in the history of the nomads. Dry years bring distress, and when they are too severe or are continued too long the nomad is brought face to face with disaster. Under the scourge of drought the great nomadic conquests of the neighboring lands have taken place. Around the margins of the steppes from China and India to Europe and Africa, history has been punctuated by repeated invasions from the grasslands. One of the greatest of these was the "barbarian" invasion of Europe which contributed to the downfall of the Roman Empire. These great migrations are thought to have been caused by cycles of dry years of more than usual severity, when the nomadic tribes were forced to flee from the steppes.[1]

[1]Ellsworth Huntington, *The Pulse of Asia*, Boston, 1907; Isaiah Bowman, "Our Expanding and Contracting 'Desert,'" *Geographical Review*, Vol. 25 (1935), pp. 43–61.

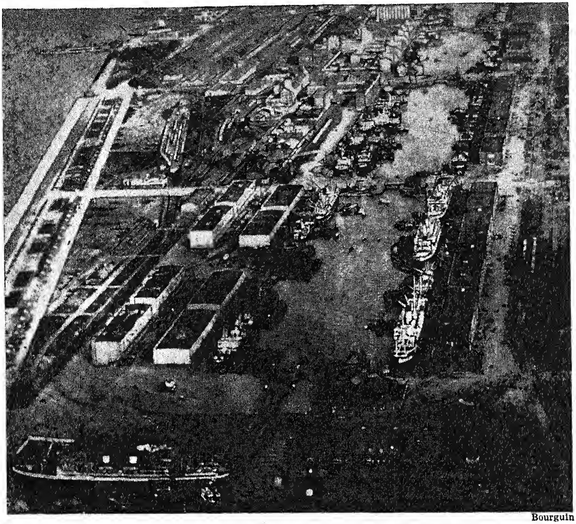


AAA Photo by Harmon

FIG. 111. *Cow punchers rounding up their cattle on the ranges of the Great Plains in Texas*

THE OCCIDENTAL OCCUPANCE

Before the middle of the nineteenth century the grasslands held little attraction for the European or American colonists. Only in the black-earth belts of European Russia and western Siberia was settlement extensive at an earlier date. In North America, when the settlers reached the prairies they hesitated and built their homes on the edge of the forest. For a long time the chief penetration of the grassy plains was by the hunters who followed the wild game, such as the buffalo in North America. Later, domestic animals were introduced, and these regions were used as natural pastures. Cattlemen on the North American plains, on the Argentine Humid Pampa, and in Uruguay adopted a seminomadic existence with their enormous herds of cattle, horses, and mules. A market for these frontier products was to be had in the settlements of eastern North America or, in South America, in the mining communities of the Andes. But the roads to these markets were long and difficult.



Bourguin

Fig. 112. *From the docks at Buenos Aires ships loaded with livestock products and grain leave for foreign markets*

The Advance of Settlement onto the Grasslands. Meanwhile the mechanical inventions were appearing which have so radically transformed the Occidental mode of life. Railroads and steamboats were the first of these to affect the grasslands by providing them with access to the growing urban markets. When the prairies of the United States were reached by through railroads from the eastern cities, between 1850 and 1860, the immediate result was an enormous stimulation of the cattle trade. In Argentina, too, railroads reached inland from Buenos Aires (1857) and Rosario and redirected the currents of trade from the centuries-old route to Bolivia. When the first refrigerator ship reached Argentina in 1877, the fact was established that frozen meat could be sent across the equator to the markets of Europe.

Almost at once, however, fundamental changes in the mode of occupance of the grasslands began to appear. With the railroads came a stream of settlers. The steel plow, first manufactured about 1837, was making the removal of the thick prairie sod a relatively easy task, the machinery for digging deep wells was making it possible for the settlers to reach dependable supplies of water, and the invention of barbed wire was making feasible the low-cost fencing of large fields. The Homestead Act in the United States, originally passed in 1862 to permit new settlers to occupy farms of not over one hundred and sixty acres practically without charge, was a great stimulus to settlement. Increasing numbers of farmers moved onto the grasslands, fenced off their fields, built their homes, and planted crops. No longer could the cattle graze at will on the unfenced range. The ancient struggle between nomadic herders and sedentary agriculturists was renewed; but this time the picturesque cattlemen found themselves unable to face the more effective occupance of the farmers, and step by step they were pushed out of existence.

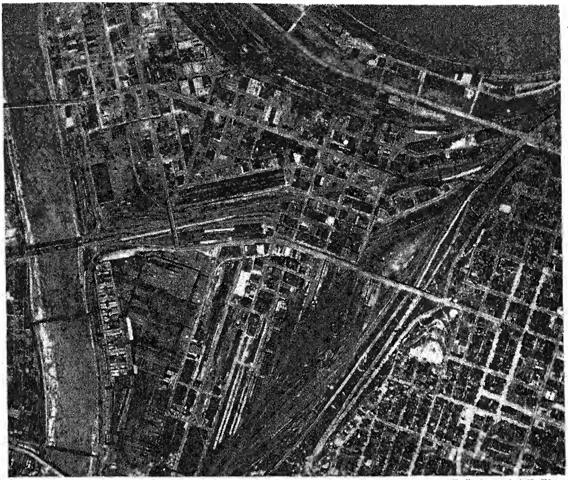
A stream of settlement has followed the construction of railroads on all the world's mid-latitude grasslands, one after the other. First, on the prairies of the United States the chief wave of settlement came after the Civil War. On the Argentine Humid Pampa the largest numbers of immigrants, chiefly from southern Europe, arrived between 1880 and 1910. In Australia the conflict between the "squatter" cattlemen and the farmers began about 1860, and by 1884 the farmers were victorious. In Russia a renewed stream of colonists poured eastward along the black-earth belt following the construction of the Trans-Siberian Railroad, which was started in 1891. This eastward migration was especially strong from 1907 to 1912. Still more recent is the settlement of the Canadian steppes.

The Transformation of the Grassland Landscapes. As a result of the Occidental occupance of the grasslands, the landscapes of these regions have been profoundly modified. Before the arrival of settlers in any important numbers the "balance of nature" remained virtually undisturbed. There was an equilibrium between the various forms of plant and animal life living together in the same area. The native grasses were

those which had developed a resistance to the hazards of the environment; the native animals had established a balance between their natural rate of increase, the food supply, and the depredations of their enemies.

Into this organized community came man. First he killed off, either for sport or for food, many of the larger native animals. Then he plowed up large areas of the native grasses and replaced them by cultivated grasses. But the effects of these simple acts went much farther than could have been predicted. Certain of the native animals of the region enjoyed either an elimination of their natural enemies or an increase in the supply of food, or both, which made possible a sudden and large increase in their numbers. The killing off of certain birds, for instance, was followed by a rapid increase in the gopher population. Some of the insects which had previously maintained a bare existence on the native grasses now found the nonresistant wheat or maize much more to their liking. The chinch bug, for example, probably fed on the native bunch grasses, whither it returns, even now, to pass the winters; but during the summer season this little native of the North American plains plays havoc with the maize, wheat, and oats. Among the native plants the sunflower, which now rapidly covers an idle field, once maintained itself precariously in competition with the prairie grasses. Thus many of the insect pests and weeds which, as a part of the natural grassland region, were effectively held in check by the competition of their enemies, were suddenly freed from this competition, so that their numbers increased enormously and they came to form hazards against which man's agriculture now has to contend.

There are spectacular stories of the introduction of new species into these regions. The Hessian fly, for instance, is a grass-feeding insect which was introduced accidentally into the United States from Europe. The great wheat fields of the North American prairies provided an ideal environment for this insect, and it multiplied at a rapid rate. Lacking any natural enemies in these new surroundings, it encountered little to check its ravages until special resistant varieties of wheat were developed. Even now the Hessian fly each year takes its toll of the American wheat crop. Still more extraordinary was the effect of the introduction of rabbits and prickly pears into Australia. Both of these,



U. S. Army A.A.F. Photo

FIG. 113. *The railroad yards of the present-day Kansas City, Missouri*

having been brought to a new environment essentially free from natural enemies, found conditions ideal and multiplied at enormous rates until both became a national menace. The prickly pear has been brought under partial control by the aid of a parasite, the cochineal scale; but every year more and more grazing land and even cropland is ruined by the rabbits.

The introduction of trees was the cause of a change of another kind in the grasslands. Around the farmsteads and villages forests were planted, so that today the buildings are all but hidden in the foliage during the summer months. On the prairies, where settlement is close, trees have been added to the landscape in such numbers that no longer is the horizon visible. At first glance these modified grasslands seem closely to resemble the cleared forest lands. The landscapes of the Corn Belt of the United States, whether in the eastern, previously forested

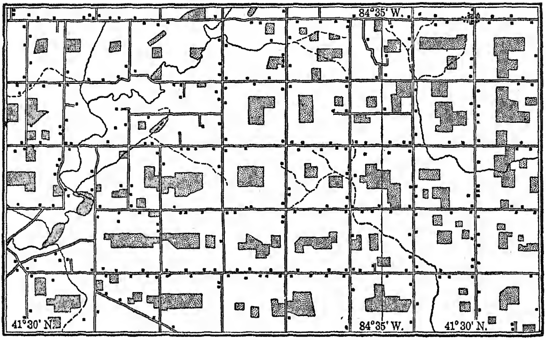


Fig. 114. *North American Corn Belt landscape in a previously forested region. The wood lots are relict patches of the native oak-hickory forest.* (From the Pioneer Quadrangle, Ohio-Michigan, United States Geological Survey)

part or in the western prairies, are strikingly similar. Yet there is a difference. The relict woodland patches in the eastern part are not uncommonly left in the centers of the sections, away from the roads (Fig. 114); but in the prairies the planted wood lots are mostly located around the farmsteads, close to the roads (Fig. 115).

Settlement of the Grasslands of the United States. The patterns and problems of settlement vary in each grassland region in accordance with the culture of the settlers. The sequence of events in the United States during the movement of the frontier of agricultural occupance across the prairies is of the utmost importance in understanding the rise of this country to pre-eminence as a world power.

At first the grasslands were used only for the grazing of vast herds of half-wild cattle. The farmers, accustomed to the forests, hesitated when they came to the edge of the open prairies where there was no shelter. The frontier of settlement in the United States had been pushed westward to the western edge of the forest by the time of the Civil War; but beyond was the land of the cattlemen. Market towns, to which the cattle were brought from the open range, were located

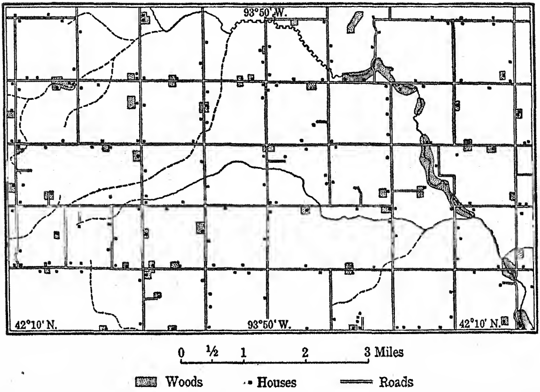


Fig. 115. *North American Corn Belt landscape in a prairie region. Some patches of relict galeria forest follow the streams, but most of the wood lots have been planted around the farmsteads.* (From the Boone Quadrangle, Iowa, United States Geological Survey)

on the forest margins—such places as Chicago, St. Louis, Minneapolis–St. Paul, and Kansas City.

The movement of the frontier of farming settlement across the grasslands after the Civil War was a major factor in the building of the modern nation. This period of occupance came at a unique time in economic history: the eastern cities were developing rapidly as large-scale manufacturing centers, supported in part by immigrant workers from Europe; the urban markets were in need of continuously increasing supplies of bulky foods, especially wheat and meat, and the railroads were providing the means of sending such supplies from the distant grasslands at costs low enough so that the whole arrangement was profitable; and as the urban industries expanded, there was a continuous demand for their products on the frontier—for steel rails, barbed wire, windmills, lumber, agricultural machines, and many other things. Then, as the settlers made good the claims to their homesteads

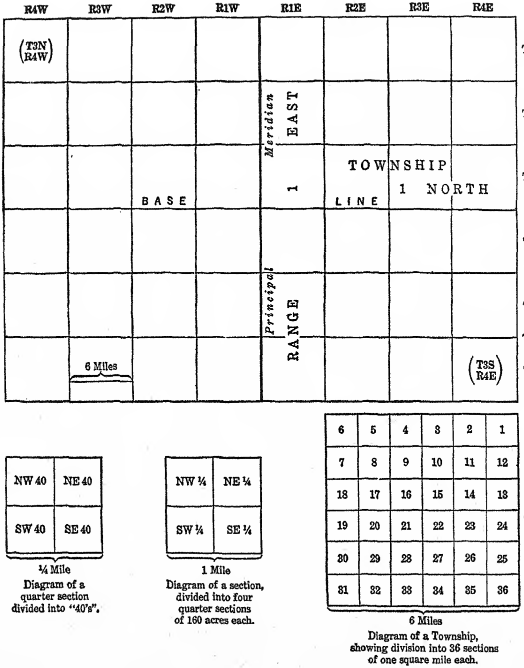


FIG. 116. *Diagrammatic layout of the General Land Office survey of the United States.* (The survey is governed in various parts of the country by a number of different principal meridians and base lines. Sample description of a forty-acre property: the NE forty of the NW quarter of section 17, township 2N, range 4E of the fifth principal meridian)

and new communities made their appearance in the rapid elaboration of settlement, each land property increased in value. Some of the original settlers sold their farms and moved westward, but the general and rapid rise of property values continued. To be sure, there were business recessions and price declines; but the trend as a whole was upward, and there seemed no reason to believe that the trend would ever stop.

This increase in land value resulting, not from the labor of the individual owner, but from the general rise in the economic life of the community, is known by the economists as "unearned increment." It was collected by many small landowners throughout the grassland region of central United States; it was spent for many of the manufactured products which in turn brought prosperity to the urban centers. Unearned increment made the Middle West of the United States one of the most prosperous economic regions of the world, and gave the American people an attitude of optimism toward matters of economic development which even today distinguishes them from people who have been less fortunate. It was amazing luck to approach the settlement of an essentially empty region of such potential productivity at just such a time in the history of mankind.

The patterns of settlement developed in this period are remarkably uniform over large areas. This is owing in part to the absence of strongly marked relief features, but also in part to the ease with which roads in a grassland can be shifted to conform to a general settlement plan. On forested plains the first lines of travel away from the rivers, which developed even before the stage of pioneer settlement, are more or less fixed as the framework to which later settlement is joined. Even where the standard survey of properties was later applied, the persistence of the first roads along the Indian trails is notable, as is illustrated by the map of Perham (Fig. 88). But in the grasslands the roads are not so rigidly fixed because they are not hemmed in by trees. Even where a regular line of travel exists across a prairie, a well-defined road is not necessarily impressed upon the landscape. As the ruts of the wagon wheels score the prairie sod too deeply, a new way is picked to one side. The result was that when the uniform pattern of properties was established the shift of the roads to conform to the right-angle lines was easy. Because the tradition of the dispersed settlement had become estab-

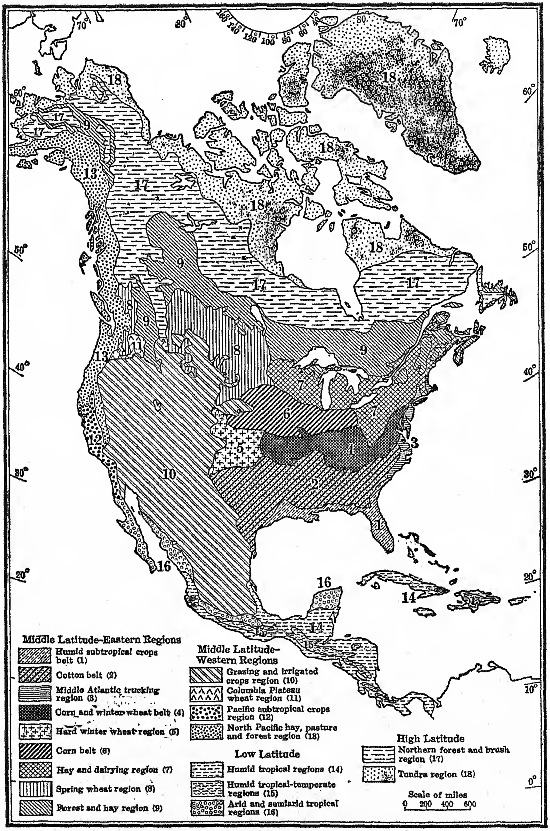
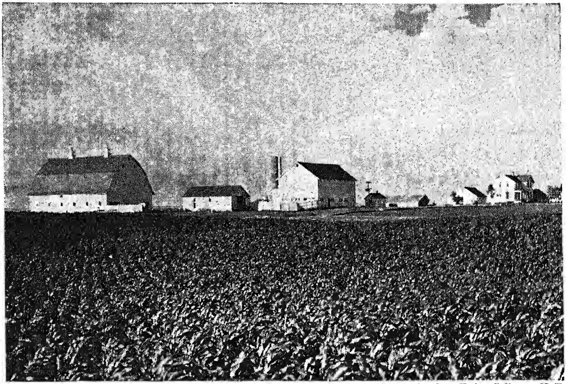


FIG. 117. *Agricultural regions of North America.* (After O. E. Baker)



J. C. Allen from Ewing Galloway, N. Y.

FIG. 118. *A Corn Belt farm in Iowa*

lished west of the Appalachians, for reasons previously described, this same pattern was carried on westward into the grasslands.

Agriculture. Maize and wheat are the basic crops of the grasslands of the United States. Both were grown first in the forested areas of Group IV farther to the east, and the patterns of crop distribution have gone through stages of development, gradually emerging in the agricultural regions we know today (Fig. 117).

The Corn Belt is unique in the whole world. In other mid-latitude grasslands there are large areas devoted to the surplus production of grains and meat; but, as we shall see, no other region shares the remarkably favorable qualities, both physical and economic, of the Corn Belt. From this one region comes a third of the world's production of maize. Very little of it, however, is marketed directly as human food; most of it is fed to hogs and cattle. From this region comes more than half of all the pork and beef consumed in the United States.

The accompanying series of maps (Figs. 119, 120) show the distribution of maize in the United States at various periods since 1839. By 1859

there was already a suggestion of maize concentration in Ohio, Indiana, and Illinois, but the outlines of the Corn Belt scarcely appeared until after the Civil War, and at that time the only cattle concentrations were on the plains of Texas (Fig. 122). By the end of the century, however, the outlines of the Corn Belt were distinct.

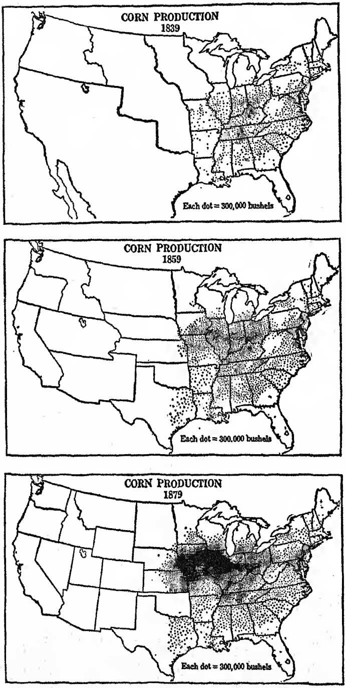


FIG. 119. *Development of the North American Corn Belt, 1839 to 1879.* (Courtesy of the United States Department of Agriculture)

The advantages of the Corn Belt, so eagerly seized by the settlers during the nineteenth century, are both physical and economic. Maize is a tropical plant which, like most other crops, produces best near its cold limits. Because of a continental position, the Corn Belt enjoys very hot summers in spite of fairly severe winters. A little farther north the climate is poor for maize as a grain, and beyond the isotherm of 66° average temperature for the three summer months maize can be grown only to cut green as a hay. Furthermore, although much of the Corn Belt is only moderately rainy, the greater part of the rains come in the warm season. The resulting hot, showery, almost tropical summers are ideal for maize. The Corn Belt has been extended westward as far as the

isohyet of eight inches in the summer months. The great productivity of this region, however, must be laid primarily to the vast area of level to gently rolling surface, little broken by steep slopes, and to the remarkable and sustained fertility of the dark-colored soils.

Nature can provide only opportunities; these same grasslands remained quite inhospitable to settlement before the era of machinery and big markets. The rise of the Corn Belt cannot be interpreted without reference to the growth of the great cities and to the expansion of the railroads which gave access to these cities. Nor can the particular kind of economy practiced in this area be understood without reference to the traditions of the American people, who demand meat rather than "corn bread."

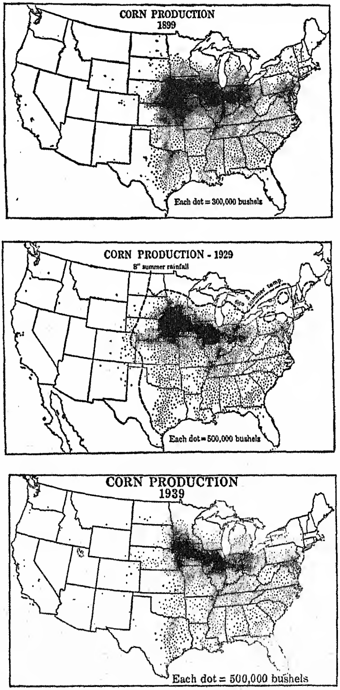


Fig. 120. *Development of the North American Corn Belt, 1899 to 1939.* (Courtesy of the United States Department of Agriculture)

Crop Combinations in the Corn Belt. In previous chapters the effect of transportation development in causing a localization of crops in areas best suited to them has been pointed out. We have seen how certain vegetables and fruits have become established and have been intensively cultivated in

those localities where the combination of climate, soil, surface, and drainage is peculiarly favorable. We must now amplify this principle; for although maize exhibits a notable localization in the Corn Belt, this region is also ideally suited to other crops which are not similarly concentrated there, and although this is one of the chief maize-producing regions of the world, only about 25 per cent of the area and 42 per cent of the cropland are used for the chief crop. Maize is associated with oats, wheat, and hay; and much of the total area is in permanent pasture.[1]

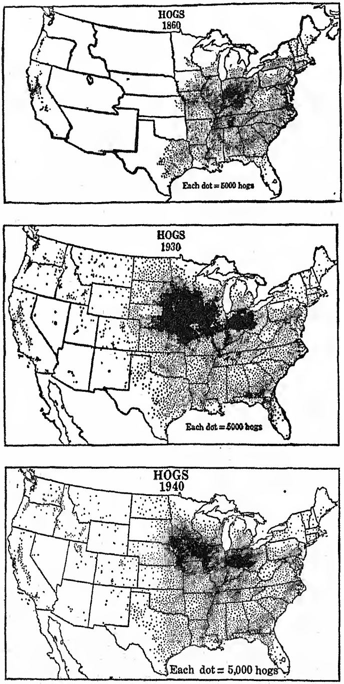


FIG. 121. *Hogs in the United States, 1860 to 1940.* (Courtesy of the United States Department of Agriculture)

There are certain tendencies in agricultural land use leading toward a specialization of crops, and there are other tendencies leading toward a diversification. We have seen that, with nothing more adequate than horse-drawn vehicles, each community is forced to depend on local sources of the basic supplies; there is little opportunity for specialization. Only very valuable prod-

[1]See the discussion of the Corn Belt in Clarence F. Jones, *Economic Geography* (New York, 1941), pp. 294–303.

ucts, for which the cost of shipment represents but a small part of the total cost, can become localized in places where the conditions of land, labor, or capital are particularly favorable. The development of railroads and steamboat lines results only in a relative change in the operation of this economic principle. Still it is the crops having the larger values per unit of weight which respond most clearly to the forces leading to localization. Such are most of the crops produced by Occidental plantations in the tropical forests: sugar, cacao, coconuts, coffee, bananas, and others. Such, also, are the fruit and vegetable crops, previously described as examples of localization. The sugar beets and potatoes which in certain parts of the Corn Belt interrupt the prevailing crop combinations have become localized in response to this principle. These very valuable products take precedence over maize, and where they are grown there is little diversification.

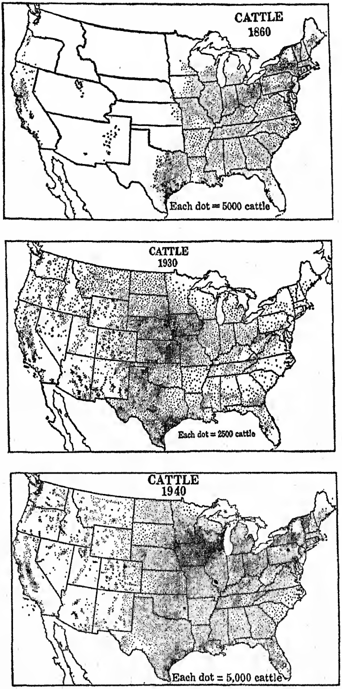


Fig. 122. *Cattle in the United States, 1860 to 1940.* (Courtesy of the United States Department of Agriculture)

Specialization of crops is also apparent in the zones around the urban centers. In these places, however, localization is brought about by the

Philip Gendreau, N. Y.

FIG. 123. *A truck garden in the vicinity of New York City*

high land values near the cities rather than by any special quality of the soil. Where land is expensive, only those crops can be grown on it which bring large returns in money income. Truck-garden zones are established on the periphery of almost all the world's cities, in many cases despite adverse conditions of climate, soil, or slope (Fig. 123).

Among the more bulky products, such as the grains, it not uncommonly happens that two or more crops are in competition for the same territory, all of them finding especially favorable physical conditions. This is the situation in the prairies of the Corn Belt, where both maize and wheat find excellent conditions of growth. In these circumstances, provided there is a market for all the competing crops, those which are otherwise most narrowly limited by physical requirements generally get the first choice of the land. Thus, in the American Cotton Belt,

U.S.D.A. Photograph by Forsythe

FIG. 124. *Picking cotton in Alabama*

although maize grows there excellently, cotton, which is more narrowly limited by moisture and temperature, occupies the best lands. In the Corn Belt, maize, being unable to grow as far coldward or as far toward the dry lands as wheat, has first choice of the land and tends to eliminate competing crops.

The diversification of crops arises chiefly from two causes. In the first place, experience has shown that soil fertility, quickly exhausted by such crops as maize or wheat, can be maintained by a rotation of crops and by the application of animal manures. During the last century, as we have seen, crop rotation and domestic animals have become important features of Occidental grain-farming. Then, too, the most efficient use of labor throughout the year is gained by crop diversification. In a one-crop system the work of planting, cultivating, and harvesting is concentrated at certain times of the year, and periods of relative idleness intervene. But the labor demands of different crops

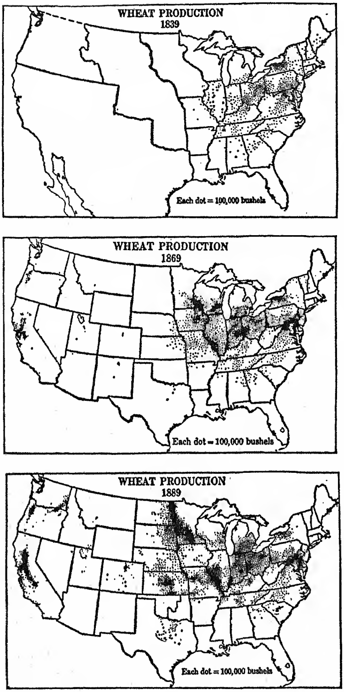


Fig. 125. *Development of the wheat regions of the United States, 1839 to 1889.* (Courtesy of the United States Department of Agriculture)

are spread differently over the seasons, so that a more uniform distribution of work is possible in regions of diversified agriculture. For these reasons other crops are associated with the dominant crop in the Corn Belt.

The operation of these various principles leads to the appearance of such specialized agricultural regions as the Corn Belt. The outlines of the region represent an adjustment between these economic principles and the physical qualities of the land. The land, however, remains as a relatively permanent basic factor; it does not become a positive force in the man-land equation unless it is significantly changed in the course of settlement—unless it is destroyed, perhaps, by wasteful methods of farming. Otherwise, the positive force is the balance of costs and prices determined by the economic conditions from year to year. Outlines of the Corn Belt are threatened with change owing to the development by agronomists of a "hybrid corn," from the use of which the yields per acre may be increased by as much as 50 per cent. The widespread use of this new

variety could result in the reduction of the proportion of land in maize, especially on the poorer soils or the marginal areas.

The Wheat Regions of the United States. Wheat, unlike maize, is mostly used directly as a human food. It is stated that this grain provides between 25 and 50 per cent of the fuel value of the food eaten by white people. It is therefore not marketed in the form of fattened animals, but must be shipped as grain. Wheat is well adapted to this method of marketing, for the hard, dry kernels can stand rough handling and can be shipped even through the rainy tropics without deteriorating.

Wheat was carried onto the grasslands of North America along with maize, but before 1870 it showed little tendency to concentrate (Fig. 125). In the decade between 1870 and 1880, however, the binders and large power-driven threshing machines were

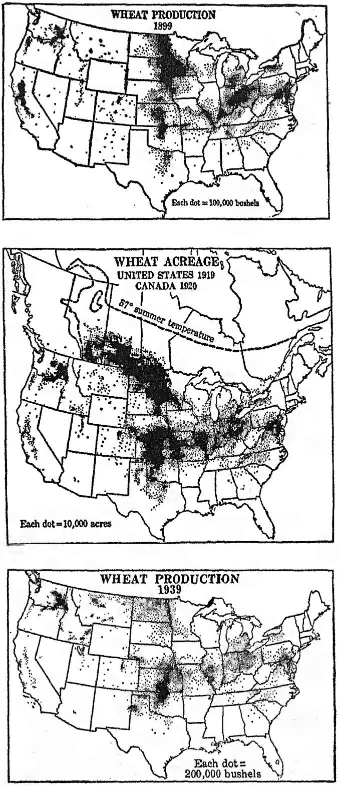
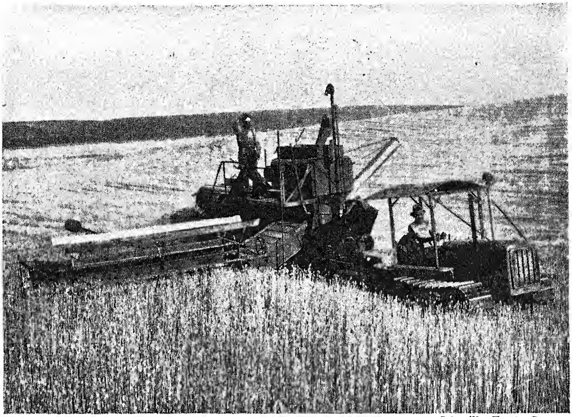


Fig. 126. *Development of the wheat regions of the United States, 1899 to 1939.* (Courtesy of the United States Department of Agriculture)



Caterpillar Tractor Company

FIG. 127. *Harvesting wheat in the Washington-Oregon area*

invented, making possible large-scale farming. The settlers advanced onto the drier grasslands in three places: in the Red River plains of Minnesota and North Dakota, in southern Nebraska and Kansas, and in the Columbia Plateau portion of Washington and Oregon. The next decade witnessed an enormous increase of production in these areas, especially on the Red River plains. The pattern of distribution as outlined by 1899 has remained essentially the same except for amplification of its details (Fig. 126).

Advantages of the Grasslands for Wheat. To interpret wheat distribution it is necessary to consider briefly the advantages which parts of these grasslands possess for wheat production, advantages which have led to the establishment of wheat as a chief crop. We are not concerned here with those areas where wheat is a minor crop, as in the Corn Belt, although these regions account for an important part of the world production. On the dry margins of the prairies and on the steppes wheat is not only dominant but, in places, occupies nearly all the cropland.

Wheat will grow under many different climatic conditions. By a process of seed selection numerous varieties have been developed which are adapted to conditions altogether different from those of the Mediterranean region. Quick-maturing varieties, for instance, have pushed the cold limits far poleward. Only barley and potatoes can be pushed farther north. Up to the present time, however, no kind of wheat has been developed that can mature in less than ninety frost-free days. Nor can the seed be ripened with certainty unless the average temperature of the three summer months is at least 57°. Most of the world's wheat is planted in the fall, starts its growth before winter sets in, and is ready for the harvest early in the following summer. This is known as *winter wheat.* Where the winters are very cold (averaging below 20° in the coldest month), winter wheat is unable to survive unless the ground is regularly protected by a deep covering of snow which is not blown into drifts. In the northern wheat areas—the Dakotas and part of the Washington-Oregon area—wheat is planted in the spring after the frost is out of the ground and is harvested in the late summer. This is called *spring wheat.*

In its native habitat wheat is adapted to cool, moist winters and hot, dry summers. The largest yields of wheat are associated with a cool, moist period in the early stages of growth; but a hot, dry harvest season is required for the best quality of grain. Although very large yields are produced in western Europe, the resulting wheat is soft and starchy and is considered to be poorer in quality than the hard, protein-rich varieties, which require hot, dry summers.[1] In regions of heavy rainfall, too, wheat is subject to numerous diseases. The rainfall limits within which the crop is grown vary with the temperature. On the poleward

[1]Early in its growth the wheat plant sends up additional stalks from buds near its roots. Only as many heads are developed as there are stalks. Branching is promoted by cool, moist weather during the early period of growth, a condition which is best provided by the cool marine climates of the continental west coasts. The largest yields of wheat occur in these regions, but the much-desired hard wheats, with their high protein content, do not thrive in these wetter climates. The following table gives the average yields of all varieties of wheat in bushels per acre:

Cool summers		*Hot summers*	
Denmark	44	Kansas	13
Belgium	36	Hungary	16
New Zealand	31	Argentina	12

side the wheat concentrations lie between the 10-inch and 40-inch rainfall lines, but in the warmer wheat-producing regions the rainfall limits become 20 inches and 70 inches. Wheat is grown both above and below these amounts, however.

The grasslands, then, especially those with severe winters, do not possess the best of wheat climates. They do possess one feature in common, however, which makes wheat-growing possible on a large scale: the great expanses of level land permit the use of machinery, and wheat is now essentially a machine-cultivated crop. As the decreasing rainfall or the increasingly unfavorable winters result in diminished yields per acre, machinery makes possible the cultivation of more acres per farm. Thus, wheat has become established on the chernozem belts of the world, where climatic conditions have made it possible to compete on more even terms with maize, and where the deep, rich soils have maintained their productivity in spite of continued use.

The Dry Margins. The settlers who pushed the agricultural frontier westward across the grasslands of the United States usually raised wheat at first, and only changed to maize later. But as the wheat farmers moved westward they did not stop at the western margin of the chernozem belt. The chestnut-brown soils beyond lured the pioneers on with promises of quick wealth, especially after a series of wet years. In the northern Great Plains three years of more than normal rainfall from 1914 to 1916, and especially in 1915, started a wave of settlement. Far out on the steppes the pioneers plowed up the short-grass sod and planted wheat. From the virgin soils large yields were gained, and, aided by wartime prices, the settlers found themselves prosperous beyond their hopes. But then came the inevitable cycle of dry years, from 1917 to 1919—all years of crop failure. Many of the farmers who managed to survive the drought, with their farms heavily mortgaged, were ruined by the drop of land values which followed the conclusion of World War I. The fields were left to grow up in weeds; the tide of abandonment was almost as strong as the tide of settlement.

A similar story can be told for western Kansas. In one county the total income from wheat farming for a 640-acre farm for the whole period from 1912 to 1934 was $21,167. This means an average income

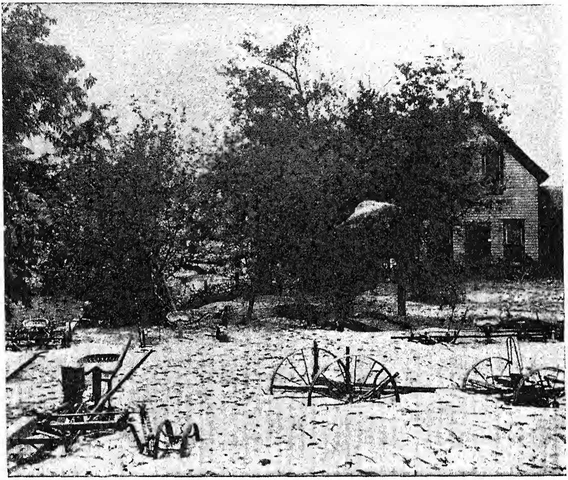


FIG. 128. *Floods as well as drought cause the abandonment of farmsteads*

of about $1000 per year for a farm of this size. But such a statistical average is far from the actual income per year. The fact is that of the total income quoted above, $20,472 was received in one year, 1920, when the farmers in that county enjoyed a rare combination of favorable rainfall and high prices. Obviously this is a system of farming which is entirely speculative, and one which requires a considerable outlay in the form of relief funds from the government.

The farmers on the dry margin who have managed to survive have learned a number of important lessons. A different agricultural technique was necessary on these dry margins in order to make permanent settlement possible. It was found that by allowing the land to lie fallow for a year enough moisture might be stored up to permit the production of a crop the following year. Thus a part of the cropland is left bare each year,—carefully plowed and harrowed to reduce the evaporation.

U. S. Forest Service

Fig. 129. *Cattle grazing on the steppes of eastern Montana*

Wheat grown with such *dry-farming* methods may yield only from six to ten bushels to the acre, although in wet years the yield may be much more than this. But, aided by machinery, the farmers ceased to care about the yield per acre, provided they could cultivate a sufficient number of acres. The Homestead Act had been changed in 1909 to permit settlers to occupy a maximum of 320 acres, and in 1916 the limit was further raised to 640 acres. Recent studies in Montana lead to the conclusion that 1280 acres, or even twice this number, are needed to provide security.[1] Furthermore, it has been found that on the steppes farming and cattle-ranching ought to be combined, so that in the dry years range cattle can provide some income to compensate, at least in part, for the crop failure.

[1]See the studies of pioneer settlement in I. Bowman, *The Pioneer Fringe*, American Geographical Society, Special Publication No. 13, New York, 1931; and *Pioneer Settlement* (by twenty-six authors), American Geographical Society, Special Publication No. 14, New York, 1932.

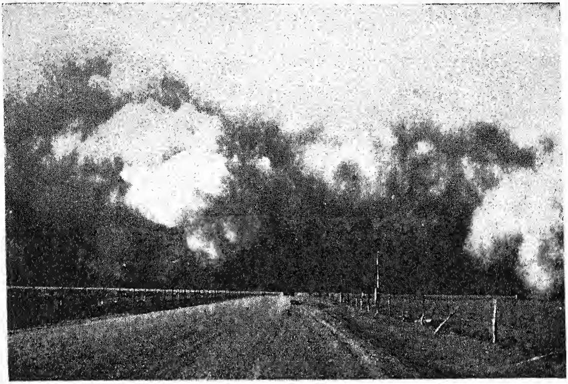


FIG. 130. *A dust storm approaching in the Western Great Plains*

Between 1930 and 1940 there was a very large movement of people away from the dry margin of the Great Plains. In 1931 there was a serious drought in the northern part of the region—from Montana to Kansas. Thereafter, in every year for ten years drought came to some portion of the Great Plains, and in both 1934 and 1936 the whole region was affected. With the droughts came the dust storms that blew the fertile topsoil from vast areas of plowed land being used for dry farming. The combination of droughts, wind erosion, and the economic depression was too much for most of the settlers who had so confidently headed westward into the steppes a few decades earlier. But there is no reason to believe that history will not repeat itself: with a return of the cycle of wetter years, and with a high world price for wheat, the whole wasteful process may be started again (Fig. 130).

Settlement of the Canadian Grasslands. In many respects the process of grassland settlement in Canada has been similar to that in the United States. There is the same pattern of dispersed farms, the same articula-

tion along the railroads, the same profit from unearned increment, and the same speculative insecurity along the dry margin. The economy in Canada is based on the production of spring wheat, for the wheat regions there are mostly too cool and have too short a growing season for winter wheat or maize. The chief movement of pioneer settlement west of Winnipeg came after 1900. In general, the densest population is established along the margin of the forest and along the mountain front, forming a crescent from Winnipeg in the east to Edmonton and Calgary in the west. The drier steppes are only thinly populated (Plate 1).

Settlement of the Argentine Humid Pampa. The Humid Pampa of Argentina forms the heart of the Argentine nation. Around its great city, Buenos Aires, is grouped more than three quarters of the productive capacity of the country. The Humid Pampa has become one of the world's leading producers of grain and meat, and Argentina leads the world in exported maize. But the story of settlement on the Argentine grasslands is very different from that in the United States and Canada.

The basic difference is the result of the attitude of the native Argentine toward land ownership. In most parts of Spanish America the pre-industrial tradition of the large private estate prevails. When the Argentine Humid Pampa was opened for settlement after 1857 (when the first railroad was built), it was quickly partitioned among a relatively small group of people. Within some 30 years the greater part of the region had been divided among 300 families. The estates were of vast size—100,000 acres or more. Furthermore, the people who owned the land were primarily interested in raising cattle, horses, and sheep, and not at all in agriculture except as it was necessary for the preparation of good pasture.

The development of the Humid Pampa was paid for largely by investments of British capital. The British built most of the railroads, they furnished the refrigerator ships to carry meat to Britain, and they sent out coal to supply Argentina. British and North American interests built the packing plants, and financed many other developments in Buenos Aires and other cities. The British wanted fat beef—not

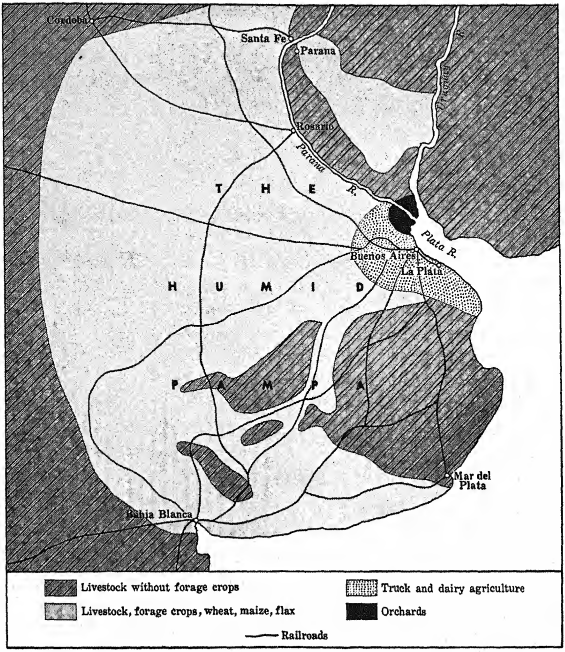


FIG. 131. *Agricultural divisions of the Argentine Humid Pampa.* (Adapted from Preston E. James, *Latin America*, New York, 1942)

the lean meat that came from the traditional Argentine herds. They introduced high-grade beef animals to Argentina.

A succession of events followed the introduction of the new beef cattle, and these events have resulted in the emergence of modern Argentina. In the first place, the beef animals had to be fed from a cultivated crop because they could not exist on the native Pampa grasses.

Alfalfa proved to be the ideal feed crop, for the climate and groundwater conditions, as well as the soils, of the Humid Pampa are excellent for this crop. But to clear the grass and prepare the land for alfalfa it proved to be necessary to plant wheat, at least for a few years. To do this the landowners hired immigrant tenants, who produced wheat for a share of the crop, agreeing that after a specified number of years they would plant alfalfa and move away. Except for an area around Rosario in the northern part of the Humid Pampa, where maize is more important than wheat, and a truck-farming area around Buenos Aires, over 50 per cent of the land is used for pasture throughout the remainder of the region, and in the southeastern part more than 80 per cent is used for pasture. Alfalfa and wheat are the crops, the latter raised by tenant farmers who remain temporarily on the land. The basic and permanent interest which determines the pattern of Argentine farm economy is the raising of high-grade animals (Fig. 131).

As a result, the unearned increment has been collected by a very small proportion of the people. There are great differences between the wealthy landowners and the workers. But on the dry margins, where the large owners can go in or out of wheat production with great ease, there is much greater flexibility of adjustment to market prices and rainfall than is the case in North America. There is a strong tendency to reduce the number of tenant farmers by increasing the use of machinery, and as this process goes on there is a movement of rural people back into Buenos Aires. Here manufacturing industries are being developed, and large numbers of displaced tenants who might otherwise create a serious unemployment problem are converted to industrial workers. The difficulty is that Argentina, more than most countries, is dependent on overseas trade. It would be impossible to consume all the potential production of grain and meat in Argentina. Furthermore, Argentina lacks coal and other sources of power. The country is struggling with problems arising from the concentration of land in the hands of a few people, the very profitable development of commercial agriculture, and the subsequent restriction of international commerce. In Buenos Aires, too, the industrial way of living is making its appearance; Argentina is in the throes of the transition from a preindustrial to an industrial society.

Settlement of the Russian Steppes. Within the territory of the Soviet Union there is a third major area of grasslands. The chernozem soil which lies under the prairie is the famous "black-earth belt" of Russia, extending from the northern side of the Black Sea northwest of Odessa eastward to the edge of the mountains near Barnaul, and in scattered patches even as far as Irkutsk near Lake Baikal (Plate 18 and Fig. 132). The black-earth belt forms a narrow band between the forests farther north and the steppes and deserts to the south. Along this belt conditions for the production of grain are excellent, but the grain belt is gradually narrowed toward the east by the convergence of lands which are unsuited to agriculture because they are too dry and lands which are unsuited to agriculture because they are too cold. Today this region is the chief source of wheat for the Soviet Union.

The story of the occupance of the Russian grasslands is one of special importance in this survey of world problems of population. It is of special importance because the latest phases have been carried out in accordance with the methods of the soviet society. In a world threatened with conflict between two major divisions of the Occidental culture, it is essential to observe as objectively as possible the conditions of settlement and the problems of man's relation to the land in a society different from our own. The grasslands offer an unusual opportunity to compare the differences which arise from differences in culture. In North America we have observed the settlement of the prairies and steppes by people of the industrial society. In Argentina we have observed the settlement of a similar region by a pre-industrial people, whose chief interest is in the raising of animals. In the Russian prairies, the steppes, we see still another similar region occupied first by a pre-industrial society, and then reorganized quite completely along soviet lines.

The grasslands of European Russia were the first such regions in the world to be successfully occupied for grain farming. In accordance with the pre-industrial tradition the land was divided into large private estates, and the work was done by the labor of serfs. Armed only with the most primitive agricultural implements, the prairie sod was broken largely by the power of human muscles supplemented by domestic animals. Under a system of virtual slavery, work was accomplished

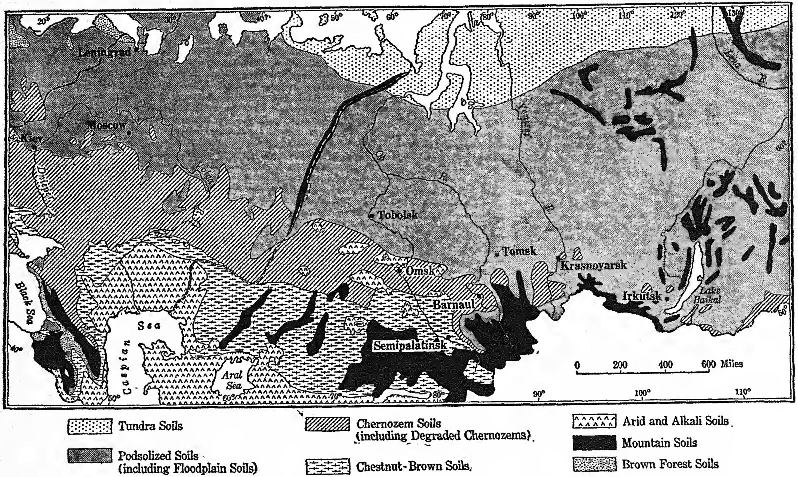


FIG. 132. *Soils of the western part of the U.S.S.R.* (Adapted from the "General Map of the Soils of Europe," Warsaw, 1928; and "Soils of the U.S.S.R." in *Pioneer Settlement* (New York, 1932), p. 248)

which elsewhere proved impossible until the age of machinery. After the freeing of the serfs, a small proportion of the peasants were able to acquire farms of their own, but most of the agricultural workers were employed on the lands of the large owners. The average size of the peasant farms was between seven and ten acres, which is too small for the support of a family in the grasslands.

Wheat was raised on the black-earth belt, not as a food for the peasants, for they generally ate rye bread, but for export. The grain was carried by wagon to the Volga River, and thence by river and canal to St. Petersburg (now Leningrad), where it was loaded on foreign ships for export to other European countries. In 1891 the Trans-Siberian Railroad was started, and a stream of pioneer settlers spread eastward into western Siberia, following the advance of the rails. Between 1897 and 1917 the population of Siberia doubled, and most of the new settlement was in the black-earth belt.

Since the emergence of the soviet society after 1917, the new leaders have attempted to bring to Russia the technical and mechanical advantages of the industrial society, but to set up quite different social and economic institutions. In order to supply the large numbers of people who were concentrated in the new industrial cities a very large increase in the food supply was needed. From subsistence farming on the black-earth belt, it was essential to develop a surplus production of staple foods.

Two kinds of farms have been set up in the grasslands today.[1] There are state farms and collective farms. The former are run by the government under the direction of farm experts. In 1939 there were 477 state grain farms, each intended to offer a practical demonstration of modern farm practices. Machinery has replaced the wooden plows which were common before World War I. The workers and their families are housed in new model villages where schooling and recreation can be carried on. But 93 per cent of the peasants work on collective farms, where they elect their own leaders and adopt their own rules. By 1935, some 72 per cent of the collective farms made use of machine-tractors; large acreages—averaging 988 acres per farm—are worked by machinery on a co-operative basis. In terms of the comforts of living

[1] J. S. Gregory and D. W. Shave, *The U.S.S.R., A Geographical Survey*, New York, 1944.

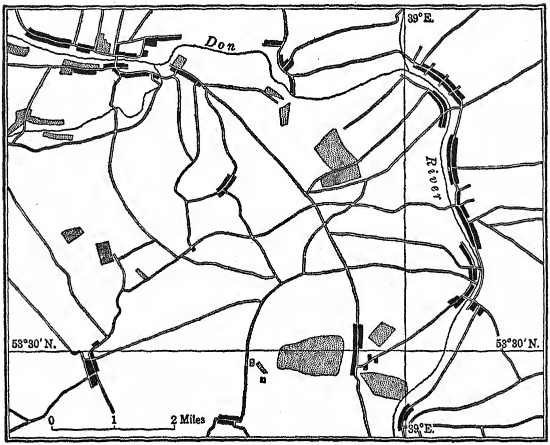
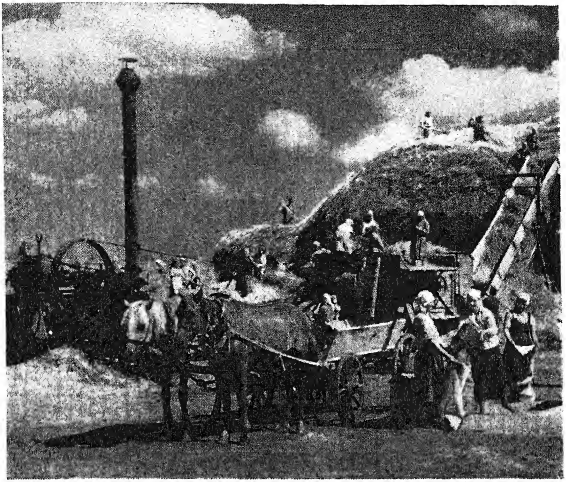


FIG. 133. *Topographic detail on the Russian steppes. Location is about 170 miles southeast of Moscow.* (From Kurkina and Chernova sheets (N 37–90 and N 37–91), Geodetic Survey Committee, U.S.S.R., 1928)

and the relief from the burden of ceaseless labor, the rural people of the black-earth belt are much better off today than they were before the Revolution; yet they are still far from reaching the material standards achieved by the farm population of the North American prairies (Figs. 133 and 134).

The Occidental Occupance of the Savannas. The Occidental occupance of the low-latitude grasslands has not gone so far as that of the prairies and steppes. The difficulties of tropical settlement are yet to be solved. As a matter of fact, the problems of colonization in the savannas are in many respects similar to those already discussed in connection with Group II. There are the same medical questions to be solved, the same difficulties of providing access to the high-altitude settlements, the same problems of the political and economic control of native



Sovfoto

FIG. 134. *Threshing wheat on a collective farm in Soviet Russia*

peoples, and the same necessity of basing the settlement on a product of commercial value.

There are numerous natural handicaps, especially on the lowland savannas, which impede the occupance by Europeans or Americans. The insect pests are even more of a menace to health than they are in the tropical forests. They spread disease not only among the human inhabitants but also among the domestic cattle, which seem peculiarly susceptible. Only poor, scrawny cattle can be produced in these regions without a very expensive transformation of the entire scene. The natural grasses are very poor as feed, so that artificial pastures of planted grasses must be prepared. Then, too, because of the seasonal alternation between flood and drought, not only must these pastures be protected by drainage systems, but they must also be irrigated during the long dry season. Although a few such developments have been carried out

—for example, near Valencia in Venezuela and on the scattered ranches of northern Australia—they represent only a negligible fraction of the savanna area. Only on the higher plateaus, as in Brazil or southern Africa, have range cattle of good quality been raised on the natural grasses.

The savannas of the Sudan present the additional difficulty, for Occidental occupance, of being already inhabited by a native population. In these regions European political or economic control may become firmly established, but actual settlement by Europeans in any numbers is unlikely.

In two places, however, Europeans have made serious attempts to occupy the savannas. These are southern Africa and northern Australia. Southern Africa, as we have seen, is a plateau of sufficient elevation to bring cool climates well northward toward the equator. In the analogous climatic position in southeastern Brazil a year-round rainfall supports a tropical forest; but on the Plateau of South Africa various types of grassland form a concentric pattern around the margins of the Kalahari (Plate 14). For hundreds of miles south of Johannesburg the vegetation cover is a pure grassland much like a tall-grass prairie (Fig. 12); to the north is a scattered tree savanna. The colonization of this area is still in the pioneer stage of experimentation. The settlements are arranged along the axes of the railroads. As yet there has been little elaboration except near Johannesburg.[1] It is not yet certain what crops will provide the best support, although the beginnings of a concentration of maize are visible around Johannesburg and Pretoria.

The European occupance of the savannas of northern Australia is also very much of an experiment, and, in general, one which seems to be unsuccessful. Of all the savanna regions this one is in many ways the most difficult to occupy. There are no mountain areas in the interior of Australia of sufficient size to give rise to large rivers. No permanent stream crosses the savannas. Furthermore, although the average annual rainfall along the north coast is heavy (about 62 inches at Darwin), it is very unevenly distributed during the year. Most of it falls between November and April during the time of the onshore summer monsoon, the average for January at Darwin being about 16 inches. From

[1] J. H. Wellington, "Land Utilization in South Africa," *Geographical Review*, Vol. 22 (1932), pp. 205–224.

May to September there is almost no rain. Irrigation would be essential for permanent settlement, yet there are no streams to supply water. At present there is a widely scattered population of sheep ranchers who maintain contact with the outside world by radio and airplane. The prospects for the occupation of this region by additional settlers are not good; in fact, the tendency is for the numbers to diminish as ranchers move away to more favorable parts of the country.

THE ORIENTAL OCCUPANCE

In all the great grassland regions of the world the experience of man in his attempt to form permanent fixed settlements has been similar. In a general way there are the same problems of securing water, of clearing the grass sod, of combating insect pests, of building houses to withstand the extremes of weather in a land without the shelter of trees or hills, and of finding a suitable form of economy to make the settlement workable. But in each region we have described, differences in human culture—in the attitudes, objectives, and technical abilities of the settlers—have produced different relationships between people and land. Underlying the broad similarity of all the regions of Group V are the detailed differences which make each area and its problems unique.

This is illustrated with special force in the story of the Oriental occupance of Manchuria, another of the great mid-latitude grasslands of the world. Manchuria (Fig. 135) is a region of long and very cold, dry winters and short, hot, rainy summers. At Harbin the average temperature of January is $-1.7°$. From October to April the ground is frozen and generally bare. The roads at this time of the year are easily passable. When the short summer comes (from May to September) the weather is hot and rainy, vegetation springs to life, the landscape changes from brown to green, and the roads are deep with mud and all but impassable. Into this region, once occupied only by pastoral nomads, came the agricultural Chinese.

Chinese Settlement. The Chinese settlement of Manchuria began over a century ago; for between 1821 and 1851 colonies were established as far north as the Sungari River. Not until 1878, however, was colo-

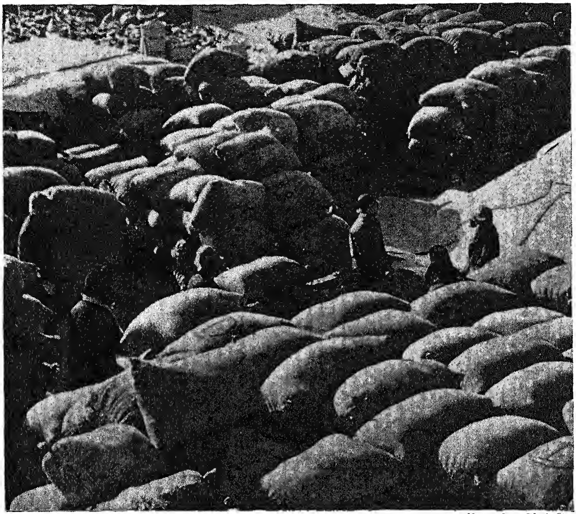
Fig. 135. *Japan and the neighboring portions of Asia.* (For definition of climatic symbols, see Appendix B, section 30)

nization given official sanction. During the last two decades of the nineteenth century a slow but steady movement of Chinese was filling the southernmost parts of Manchuria. When the railroads were built, after 1900, the stream of settlement, as in the Occidental grasslands, was rapidly augmented. It was not until 1926, however, that the numbers of immigrants into Manchuria became spectacular. From 1926 to 1928 over a million people a year moved northward, probably the greatest migration in human history. Most of these colonists came from the famine zones of North China, chiefly from Shantung. After their arrival in Manchuria a few took advantage of the railroads, but the greater number struggled northward on foot to find room for settlement.

The Chinese mode of expansion on this frontier is quite different from the expansion on Occidental frontiers. The North American pioneers, for instance, traveled far beyond the margins of established settlement and located their homesteads in a zone of very thin and scattered population. Similarly, the older Russian expansion eastward along the black-earth belt sent colonies far out in advance. Not so the Chinese. This frontier spread northward "like a drop of oil," presenting a solid front of dense settlement against the unsettled grasslands beyond the frontier, still occupied by pastoral nomads.[1]

The story of settlement in Manchuria is greatly complicated by the fact that this region is of interest not only to the Chinese but also to the Soviet Union and to Japan. For some 2000 years, up to the end of the nineteenth century, Manchuria was important chiefly as a marginal part of China. To the Chinese it is known as the "three eastern provinces," and only the foreigner uses the name Manchuria. In 1896, however, the Chinese government permitted Russia to build the Chinese Eastern Railway to serve as a shortcut on the Trans-Siberian line to Vladivostok. The Russians, seeking an ice-free port, built a branch southward from Harbin to Port Arthur, near Dairen. The activities of the Russians brought them into conflict with the Japanese, who desired both protection from the advance of the Russians into eastern Asia and also the right to exploit the mineral resources of Manchuria, which include both coal and iron ore. As a result of the Russo-Japanese War

[1]R. B. Hall, "The Geography of Manchuria," *Annals of the American Academy of Political and Social Science*, Vol. 152 (1930), pp. 278–292.



Natori from Black Star

Fig. 136. *Bags of Manchurian soybeans ready for export*

of 1904–1905, Japan took over the southern branch of the railroad and renamed it the South Manchuria Railway.

These railroad lines were administered by essentially independent corporations, which therefore made them lines of Russian and Japanese penetration into Chinese Manchuria. The corporations were responsible for the policing of zones on either side of the rails, and they built mines and factories and developed cities. When the Japanese seized Mukden in 1931 and set up a puppet government for "Manchukuo," the chief purpose was not to find new lands to colonize, but rather to have a free hand to develop and utilize the commercial resources of the country. In comparison to the millions of Chinese, few Japanese ever came to Manchuria. But the Japanese developed the coal mines, especially the mines at Fushun near Mukden, where the thickest coal seam in the

world (417 feet) is located. At Anshan, south of Mukden, large iron and steel works were built. For Japan, poor in coal, the control of Manchuria seemed essential. As a result of World War II many of these industrial establishments were destroyed or removed.

Manchuria is still a focus of conflicting interests. At the end of World War II it was returned to China, but the interest of the Soviet Union and of Japan in the region continues. As one or another becomes relatively stronger or weaker as a national entity, this balance is reflected in increasing or decreasing influence in Manchurian affairs. China, torn by internal conflict, is not yet strong enough to stand against the continued influence of foreign powers. But while nations jockey for commercial or military advantage, the Chinese farmers have occupied the land with a stubborn and enduring attachment that would be difficult to break.

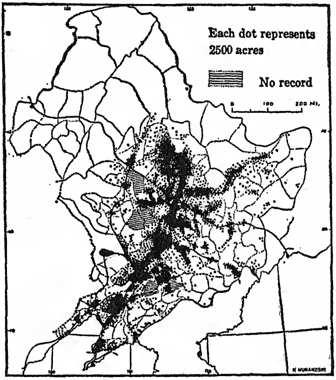


Fig. 137. *Soybean acreage in Manchuria*[1]

The Agriculture. Settlement in Manchuria was formerly based on subsistence grain-farming. Even today the most important subsistence crops are a giant sorghum known as kaoliang, millet, and wheat. During the present century, however, the soybean has become more and more of a commercial crop, after the mode of the Occident. This remarkable plant is a native of eastern Asia and has been cultivated in China for many centuries. Its introduction into Manchuria was very

[1]From *Land Utilization Maps of Manchuria*, by Nobuo Murakoshi and Glenn T. Trewartha. Courtesy of the *Geographical Review*, published by the American Geographical Society of New York.

successful. In 1908 a shipment to England found an overseas market, and since that date exports of soybeans, bean cake, and bean oil have brought a steady cash income (Fig. 136). The soybean has become particularly important to the Japanese as a fertilizer for their heavily overworked agricultural lands. The distribution of soybeans in Manchuria (Fig. 137) reveals the influence of the railroad lines on the pattern of agricultural settlement. The chief concentration of this crop is in the Sungari Valley in the vicinity of Harbin.

Conclusion

From Manchuria across Siberia to Europe and Africa, from the tropical savannas to the prairies of the Americas, different peoples at various periods of world history have sought to establish themselves on the grasslands. For some people success was never attained. The spread of tropical grasses into the overworked clearings of the forest dwellers was a signal for the abandonment of the land. In only a few places could hoe cultivators wage a victorious battle with the grass,—chiefly where they could occupy the lands in great numbers, as the Chinese have done. The cultures with domestic animals maintained themselves perilously on the steppes of the Old World; but, scourged by the recurring cycles of drought, these nomadic peoples have poured periodically into the neighboring regions in great waves of conquest and migration which have punctuated the course of history of all the nations from China and India westward into Europe. For a time the Europeans also established a nomadic or seminomadic occupance of the grasslands. Then, as the machinery of the Western world made possible the shipment of products from distant places and also solved the chief difficulties of permanent grassland settlement, namely, grass and scarcity of water, a wave of colonization brought a rapid and far-reaching transformation of the grassland scene. Occidental agriculture became established in accordance with the principles which govern the economics of the Western world. The conquest of at least a part of the grasslands seems to be secure. Who can predict that some of the experiments now being tried in the tropical grasslands may not also prove successful and pave the way for a new migration?

GROUP VI

THE BOREAL FOREST LANDS

Seasonal change reaches a maximum in the boreal forest lands. In no other part of the world does the aspect of the face of the earth undergo such a radical transformation rhythmically, in the course of the year, as in these forest lands of the higher middle latitudes of the Northern Hemisphere. The intense cold and long hours of darkness during the winter enforce on the vegetation a long period of rest. During this time the contour of the land is smoothed by a blanket of snow, and the rivers and lakes are locked in a casing of ice. At first the longer hours of sunlight in the spring seem to make little impression on the frozen land; but suddenly, in May or June, the bare ground is revealed, the ice breaks up and is carried downstream in great thundering, chaotic masses, and the long-slumbering vegetation almost bursts into vigorous life. A carpet of flowers quickly covers the ground left bare by the melting snow, and the air is filled with myriads of insects. This is the brief period of breathless activity for all the inhabitants of the forest,—all except man, the intruder, who finds travel difficult when he tries to penetrate the thick forests and bogs away from the navigable rivers. Only where agriculture is attempted is this a busy period for the human inhabitants. With the first touch of fall the broadleaf trees turn yellow or red, the insects disappear, and the land animals seek a shelter for the long winter hibernation. Great numbers of migrating animals, especially birds, start southward. First with a touch of frost, then more firmly with a grip of ice and snow, winter fastens its fingers on the land. The long, dark night sets in. Then, from their summer refuge near the rivers, men move out into the forest, traveling easily on skis or snowshoes or sledges over the snow-covered surface or along the smooth ice-covered rivers. These are the hunters, trappers, and lumbermen who extract from the forest at this time its toll of timber and furs (Fig. 138). No landscapes, not even those of the tropical savannas, could change more than this in the course of a year.

The climatic background of this seasonal change is related to an extreme continental position. Great ranges of temperature are asso-

ciated with wide expanses of land, for only away from the oceans can great contrasts between warm summers and cold winters be developed. Range of temperature, we have said previously, increases with increasing latitude and distance from the sea. Since all the continents taper to the south, no large expanses of land occur in the middle latitudes of the Southern Hemisphere; only north of the equator is land and water distribution effective in producing extreme continental climates. The northern lands where these extreme climates prevail are the regions of Group VI.

The Land

VEGETATION AND CLIMATE

The boreal forests which extend from west to east across the continents of the Northern Hemisphere, poleward of the deserts and grasslands, are dominantly coniferous. Farther equatorward on both the eastern and the western sides, as we have seen, lie the mixed forests of Group IV. The predominance of conifers north of the mixed forests does not mean that the rigorous climatic conditions of the higher middle latitudes are more suitable to these trees, for actually conifers grow much better in regions of milder climate. But only in the north are they freed from the serious competition of broadleaf species.

The Taiga.[1] The northern coniferous forest, or *taiga*, can be contrasted in almost every respect with the tropical selva. To be sure, both are evergreen; but this resemblance is only superficial, for the evergreen conifers of the taiga do not enjoy the year-round growing season of the evergreen broadleaf species of the tropics. Then, the taiga is composed of a few simple associations instead of a great variety of kinds of trees. Spruce, fir, larch, and pine are the chief conifers, and these are combined with such broadleaf species as aspen, birch, beech, maple, and willow. These forest regions, except in northern Manchuria, lie north of the range of the oaks. Among the most common associations are the spruce-fir forests of North America, with larch (tamarack),

[1] "Taiga" is a Russian word referring to the northern virgin forests.

Canadian National

Fig. 138. *Trappers making camp in northern Quebec*

cedar, and maple occurring along with spruce and fir in the swamps; or the fir, birch, and aspen forests of western Siberia; or the larch and fir forests of eastern Siberia. Pure stands of pine are found on some of the sandy soils, much as on the similar lands farther south in Group IV. The conifer forests are interrupted by broadleaf enclaves along the river banks or in some of the swampy areas, or where these species have sprung up as second-growth forest after the conifers have in one way or another been removed.

The density of the stand of trees in the taiga varies greatly from place to place, but even in the most favored spots these forests do not form such a thick cover as the selva. Although many valuable stands of timber are found, probably the greater part of the land is covered by poor, stunted, and knotted trees of little value as timber. At the northern limits of the forest individual mature trees, centuries old, have reached only the stature of small bushes. In marked contrast to the selva, the forest floor in many areas is littered with fallen trunks and branches or with bundles of upturned roots, which, because of the high pitch content of the wood and because of the cool climate, decay very

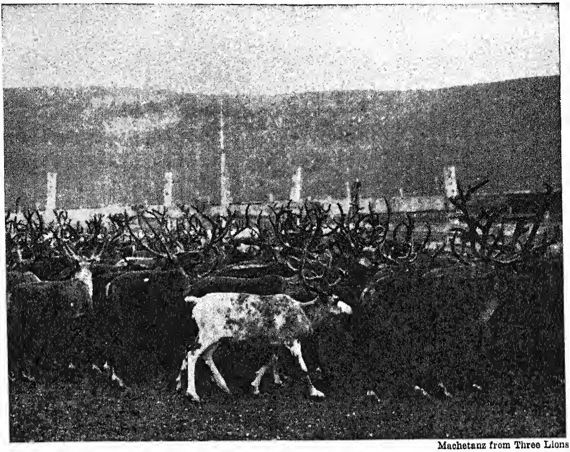
slowly. Especially in the swampy places the underbrush is so thick that passage through the forest may be extremely difficult.

The pitch content of the conifer renders it peculiarly liable to destruction by fire. Where lumbering operations are being carried on, sparks from the mills or camps frequently catch in the piles of slashings. In dry weather fires start very quickly, and once well under way are almost impossible to check. Few, indeed, are the northern forests in which charred trunks do not give evidence of at least one destructive fire.

The clearing of the taiga, whether by extensive lumbering or by fire, is not followed by a rapid return of the original species. At first only a low growth of bushes appears among the stumps. Then, instead of conifers, the first trees to gain a precarious foothold on the land are the broadleaf types, chiefly birch and aspen. In Siberia this second-growth enclave of broadleaf types is called "white taiga," as opposed to the dark-green fir forests, which are called "black taiga." Only after a long period of time does the slow growth of conifers reproduce the climax forest.

The Native Animals of the Taiga. In another respect the taiga differs from the selva. Instead of lacking large ground animals, it is the habitat of an animal population of extraordinary variety and number—an animal population which derives most of its food supply from the aquatic life in the numerous rivers, lakes, and swamps. In fact, in the more northerly sections the forest animals are of much greater value as a resource than the timber which shelters them. In these forests roam the world's chief fur-bearing animals; minks, martens, muskrats, foxes, wolves, badgers, bears, beavers, squirrels, sables, and ermines are included in the long list. There are also several large ungulata, chief of which are the deer, the moose, the caribou, and the close relative of the caribou—the reindeer (Fig. 139).

The Climate. Temperature is the most significant climatic element in these regions. Fundamental in the production of the boreal forest landscapes, with their marked seasonal contrast, is the alternation of long, severe winters and short, cool summers. Especially in the conti-



Machetanz from Three Lions

FIG. 139. *Summer roundup of reindeer in Alaska*

nental interiors very large ranges of temperature between the average of the coldest and warmest months are experienced. For example, Winnipeg, in Manitoba, has a range of 70.3°, between an average of −3.9° in January and 66.4° in July; and Dawson City, in the Yukon, has a range of 82.4°, from −23.1° in January to 59.3° in July. As might be expected, the most extreme ranges of all are found in the interior of the largest land mass, Eurasia. The little town of Verkhoyansk, in northeastern Siberia, holds the world's record for the range between the average temperature of its coldest and its warmest months. January averages −58.2°, and July averages 59.9°—a range of 118.1°. The lowest temperature ever recorded at Verkhoyansk is −90°; but at this same place a July temperature of 93.5° has also been recorded. Even lower winter temperatures have been reported from a place called Oimekon, where a weather station has been maintained since 1928. A minimum of −108° was reported unofficially for this place, which is

the lowest temperature ever observed in free air at the surface of the earth. Both these places are located in valleys among the low mountains of northeast Siberia where air drainage during calm, clear nights produces exceptionally low temperatures. Generally the winter temperatures in the northern parts of Group VI are not quite so low as these extremes: $-78°$ at Fort Yukon in Alaska, $-81°$ on the lower Mackenzie River in Canada, $-88°$ on the lower Lena River in Siberia. At all these places summer temperatures in the 90's are normal.

The winter temperatures are by no means so critical as the summer temperatures and the length of the growing season. Even though the summers are short, this is more than compensated by the long hours of sunshine. Poleward of latitude 55° or 60° N. the number of hours of possible sunlight per day during June increases rapidly to a maximum of twenty-four hours near the arctic circle (Fig. 140). At these latitudes it is not sufficient to measure the growing season in terms of frost-free days. Instead, it must be measured by the total number of hours of sunlight which come while the air temperature is over 42.6° (below which the vegetation growth ceases). Because of the very rapid rate of growth resulting from the long hours of sunshine, wild plants and crops extend considerably farther toward the north than might be expected.

The forests of Group VI, like those of Group IV, run diagonally across the continents (Fig. 51 and Plates 10 and 18). On the west coasts the boreal forest is more than 10° farther north than on the east coasts. The southern limit of the forest in Alaska is about 55° N., and in Scandinavia about 60° N.; in northern Maine and in eastern Siberia the southern limit is south of 45° N. The diagonal arrangement is owing, as we have seen, to the contrast of warm and cold ocean water on the two sides of the continents in higher middle latitudes. There is an important difference to be observed, however, between the northern limit of the boreal forest in Europe and North America. In Europe the warm North Atlantic Drift runs northward along the coast of Norway into the Arctic Ocean, bringing ice-free conditions around northern Norway and even some distance beyond (Fig. 156). But the barely submerged range of mountains which forms the Aleutian Islands shuts out the warm Kuro Siwo from Bering Sea. As a result the boreal forest

does not reach the coast of Alaska, which is tundra-covered even in the Aleutian Islands well south of 60° N.

The boreal forest is not broken by the dry lands in the continental interiors, as are the forests of Group IV. It extends all the way across the Northern Hemisphere continents north of the grasslands. Its limits are closely related to the temperatures of the summer months. The northern limit, where the boreal forest borders the arctic tundra, corresponds closely to the isotherm of 50° average temperature for the warmest month. The southern limit, where the boreal forest borders the mixed forests of Group IV, is very close to a line drawn through places which have three months averaging over 50° and a fourth month which averages just under 50°. Where four months average over 50° the summers are long enough so that the oaks and other trees characteristic of the forests of Group IV can compete successfully with the conifers except on areas of porous soil.

The rainfall over most of the boreal forest regions is low. Only on the continental margins is the total annual precipitation greater

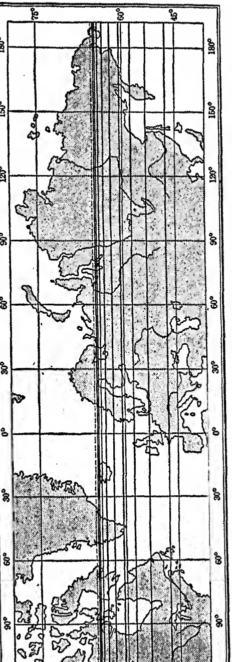


FIG. 140. *Hours of sunshine north of 45° on June 21.* Based on the sun's center and corrected for refraction. (Computed by A. D. Maxwell)

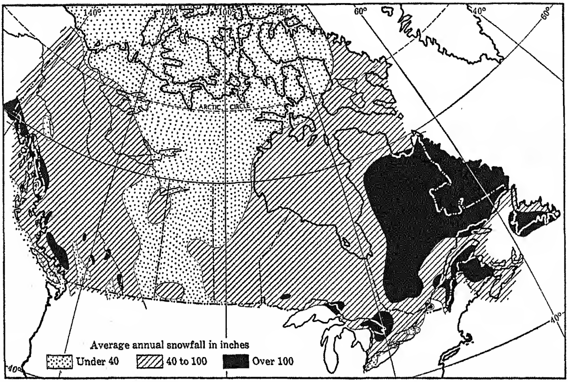


FIG. 141. *Mean annual snowfall of Canada.* (After Koeppe)

than 10 inches. Furthermore, most of the rain comes in summer, and the winters are characteristically dry and clear. This is owing to the position of these regions in the world pattern of climates. We may recall that the cold air masses which move southward over the middle latitudes of the Northern Hemisphere originate over the Arctic Ocean, Greenland, and the higher middle latitudes of North America and Eurasia in winter. Although there may be heavy frosts where cold air is accumulating, there can be no precipitation because air is settling rather than rising. The skies are cloudless, which promotes the radiation of heat from the ground and the further chilling of the air in contact with the ground. During the winters the area of cold air accumulation is so large that no warm air masses can bring moisture to it. Only on the continental margins is there much snowfall (Fig. 141). Contrary to popular belief, supported generally by the "movies," Siberia in winter is a land of little snowfall; the ground is mostly bare or covered with accumulations of frost. Because of the intense cold and the lack of a protecting blanket of snow, the small rivers and marshes freeze solid, and the ice on lakes and larger rivers is so thick

that it can support the heaviest trucks and machines, even locomotives pulling loaded trains.

The average annual rainfall of the regions of Group VI is much less critical than the temperature, however. Because even in summer the temperatures do not average very high, the evaporation is never very great. At Verkhoyansk, for example, where the average annual rainfall is only 5.2 inches, the evaporation is so low that crops can be raised with no thought of irrigation. Actually a large part of the area of Group VI is covered by marshes and bogs, some of them permanently frozen underneath. In summer, when the ice melts and the surface of the ground thaws out, large areas become all but inaccessible for people who must travel on the land.

SURFACE FEATURES AND DRAINAGE

The prevalence of lakes and marshes in Group VI, however, is not solely the result of low evaporation. The surface features and drainage also contribute to this condition. Two chief processes have been at work in sculpturing the landforms of these regions: glaciation and running water. In both cases, for reasons we shall see, lakes and marshes are commonly produced.

The Surface Configuration of Group VI. On both sides of the North Atlantic Ocean, in northeastern North America and northwestern Europe, there is a remarkably similar development of the surface features (Plates 9 and 17). This part of North America is occupied by the Laurentian Upland, in the midst of which is found the great indentation of Hudson Bay. The southern end of this hilly region in southern Canada and in parts of the United States is within the borders of Group IV. In Europe the Scandinavian Upland occupies part of Finland and most of Sweden and Norway. In the midst of this upland is the Gulf of Finland. Both uplands are made up of knobby hills rising above extensive marshy or lake-filled valleys. Within the uplands major terrain features are formed by long and sharply-marked escarpments following old fault lines through the ancient geologic formations here exposed at the surface. Both uplands rise gradually from the

Three Lions

FIG. 142. *A village in the Scandinavian Uplands in Norway*

continental interiors toward rims which face the Atlantic. The sea face of this escarpment in Labrador and in Norway is steep and rugged, forming what looks from the sea like a range of high mountains; yet only in southern Norway and in northern Labrador can it be classified as mountainous, for elsewhere, on climbing to the top, one finds a rolling hilly surface sloping gradually inland. Both uplands are bordered around their margins by cuestas which mark the upturned edges of the resistant sedimentary formations.

Bordering these hilly uplands and their marginal cuestas are vast plains which extend from the lower middle latitudes of both North America and Eurasia northward to the Arctic Ocean. These lowlands in the north are drained by three great north-flowing rivers: the Mackenzie, the Ob, and the Yenisei.

Immediately east of the Yenisei in Siberia, the moderately-dissected

plateau of eastern Siberia rises abruptly from the lowlands of the west. This vast level-topped upland fills most of the area between the Yenisei and the Lena, reaching from the mountains of central Asia to the shore of the Arctic Ocean. A similar kind of terrain is found in the Yukon Valley of Alaska between the Alaska Range and the Brooks Range. The Yukon and its tributaries pass through this plateau in steep-sided valleys.

Northeast Siberia, east of the Lena Valley, is composed of ranges of high mountains, rising distinctly above a low mountain country. Along the arctic coast there is a wide coastal plain, and another narrowly confined lowland connects the Bering Sea with the Sea of Okhotsk north of Kamchatka.

The Extent of Glaciation. These various natural divisions of Group VI have been sculptured in detail by two quite different processes. A considerable area was never covered by the ice of the continental glaciers, and here the landforms have been produced chiefly by running water. Glacial landforms, however, have been only very slightly modified by postglacial stream erosion in the other parts of the group.

Since glaciers can be formed only where so much snow falls during the winter that it does not all melt away during the summer, the places most favorable for ice accumulation are in the regions either of heavy snowfall or of cool summers, or of both. Such places are found in the high latitudes or on the snowy continental margins of higher middle latitudes. It is believed that a climate not radically different from that of today was needed to produce the continental ice sheets of the Pleistocene.

The areas of the world covered by Pleistocene ice are shown on the map (Fig. 143). In North America the chief centers of accumulation were in the far west on the snowy mountains of the west coast, and on the Plateau of Labrador, east and south of Hudson Bay. From these centers the ice spread chiefly south, east, and west. The Labrador ice sheet extended as far south as Long Island. Its southern boundary crossed the Appalachians north of Pittsburgh, and thence followed roughly the line of the Ohio and Missouri rivers into the central part of the continent. A small area in Wisconsin was never covered by the

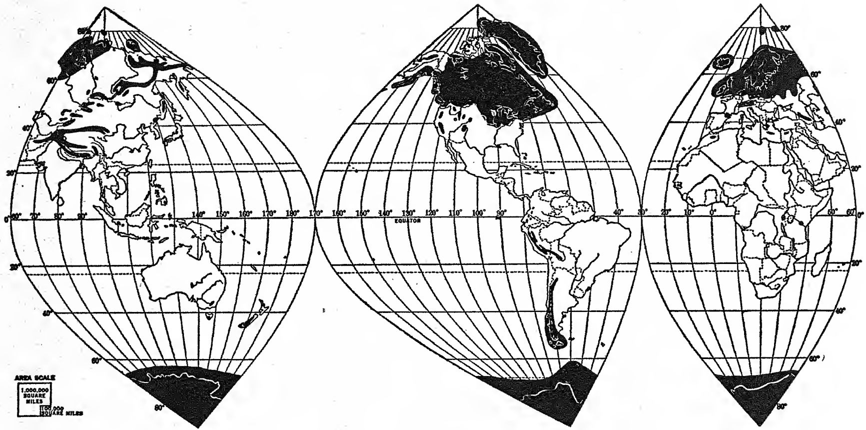
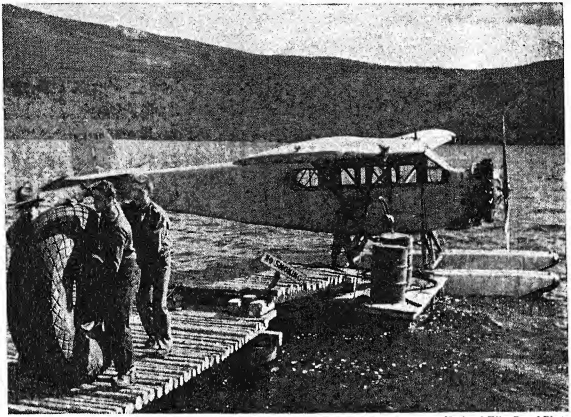


Fig. 143. *Major areas of Pleistocene glaciation.* (After E. Antevs, "Maps of Pleistocene Glaciation," *Bulletin of the Geological Society of America,* Vol. 40 (1929), pp. 631–720)

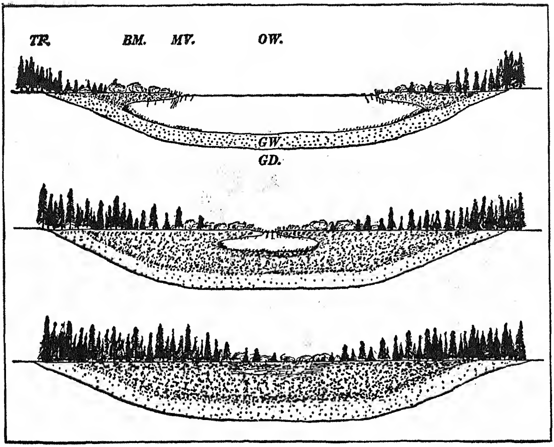


National Film Board Photo

FIG. 144. *A plane equipped with pontoons at a lake in northern Canada*

ice, although it was at one time entirely surrounded. The ice crossed Hudson Bay and covered the plains of central Canada as far north as the Arctic Ocean, but the Yukon Plateau was never glaciated. Ice still covers Greenland and parts of Ellesmere Island. In Europe the chief center of ice accumulation was the northern part of the Scandinavian Peninsula and Finland, from which the ice spread southward over most of the British Isles and, on the Continent, as far as the mouth of the Rhine and the highlands of central Europe. Eastward, however, glaciation probably extended only a short distance beyond the Urals. Most of the great interior of Siberia, with its light snowfall, was never glaciated. In the Southern Hemisphere glaciation was extensive in the southern Andes and the New Zealand Alps. The largest area of accumulation was the Antarctic Continent, which is still ice-covered.

Lakes and Swamps. In glaciated territory, whether the landforms are dominated by the processes of erosion or of deposition, innumerable depressions, large and small, are formed. If these are deep enough,



TF. = Taiga
BM. = Bog meadow on floating bog
MV. = Marginal vegetation
OW. = Open water
GW. = Glacial wash
GD. = Glacial drift

FIG. 145. *Diagram to illustrate the filling of a pit lake by vegetation.* (After C. A. Davis)

they hold lakes. On the crystalline rocks of the hilly uplands the ice carved a surface of alternating low rocky ridges, smoothed and bare of soil on top, and bog-filled or lake-filled hollows. The similarity of the landscapes developed chiefly by glacial erosion on the crystalline rocks of the Laurentian and Scandinavian uplands is striking. In Finland alone, for example, there are some thirty-five thousand lakes, covering nearly a tenth of the total area of the country (Fig. 232). In North America a series of large lakes have been formed along the margin between the crystalline rocks and the sedimentaries. In the south are the Great Lakes. Northward, arranged along this geologic boundary, are Winnipeg, Athabaska, Great Slave, and Great Bear lakes. In addition to these larger water bodies, smaller lakes or marshes nestle in

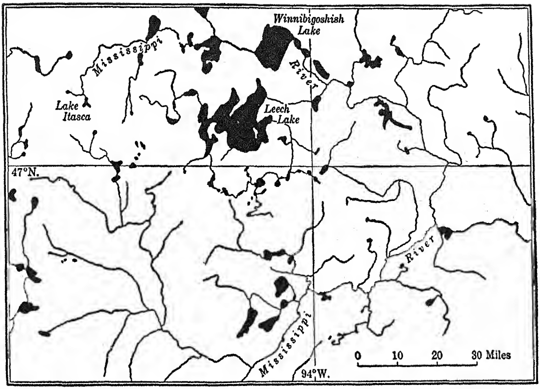


Fig. 146. *Irregular drainage of a glaciated area: the headwaters of the Mississippi River in Minnesota.* (United States Geological Survey)

almost every depression. Travel by airplanes, equipped in summer with pontoons and in winter with skis, is an easy matter in these regions, where landing places can be found every few miles (Fig. 144).

On the lowlands the glacial landforms are chiefly those of deposition. Here the greatest variety and confusion of surface topographic features appear, marked by only a vague festooning of the moraines. Some of these areas contain even more lakes and swamps than the hilly uplands.

In whatever manner lakes may be formed, they are only temporary features of the land in point of view of geologic time. Not only are their outlets being cut down, thus lowering the level of their waters, but also their basins are being filled with material washed into them. Throughout these glaciated regions all stages in the extinction of lakes can be found, from open water bodies to marshy flats from which all signs of open water have disappeared. Along with the gradual filling of such depressions, there is a fairly definite succession of vegetation (Fig. 145). First, water lilies and sedges grow on the margins of the

open water. These gradually form a floating bog which extends out from the solid shore. The floating bog becomes thicker until it fills in sufficiently to form a marsh, and various shrubs and bushes crowd out the sedges. The first trees to appear are usually larch (tamarack) in pure stands; later, as the marsh becomes more solid, in the regions of Group VI spruce follows and crowds out the larch. These various elements in the succession can all be identified in more or less concentric arrangement around lakes in process of extinction.

Rivers in Glaciated Territory. The drainage patterns in glaciated country are very different from those developed by more normal processes. Because of the blocking of preglacial valleys and the character of the surface left after the retreat of the ice, the rivers in such country are extremely irregular and winding in their courses. In many cases they wander aimlessly from lake to lake, completely changing their direction of flow as they proceed downstream (Fig. 146). In unglaciated territory, on the other hand, the stream patterns are the usual dendritic or trellis types.

The regimen of the rivers in glaciated country is remarkably uniform. The many lakes regulate the flow of water so that only a protracted drought can have much effect, while sudden rains must be excessive to produce much of a rise.

Floodplain Swamps. An exception to this statement, however, is found in the cases of the great north-flowing rivers of this group—the Mackenzie, the Ob, the Yenisei, and the Lena. These rivers are subject to extensive spring floods, and the lowlands, even where they are not glaciated, do not dry out rapidly after the water recedes. This irregular regimen arises from the conditions of the spring thaw. Since the headwaters are freed earliest, while the lower portions of the rivers are still incased in ice, great jams are the result, and behind these jams the water backs up over a large territory. The floods of the Ob are as much as thirty-five miles wide in some sections. Permanently water-logged surfaces, in many places underlain by peat, are common in all these regions, covering as much as 75 per cent of the total area in the lowlands north of Tobolsk. In Canada the name "muskeg" is applied to such surfaces.

THE SOILS

The mature soils of Group VI are well developed only in the unglaciated areas. In the regions covered by glacial deposits the time that has elapsed since the retreat of the ice has permitted only the beginnings of soil development. In both glaciated and unglaciated territory, moreover, no mature soils can develop in swampy places.

The soil type toward which the immature regoliths are developing, and which is represented in mature form over much of Siberia, is the *podsol*.[1] The podsol profile is distinctly shallower than any of the other mature profiles (Fig. 59, *A*), in few places reaching depths greater than from eighteen inches to two feet. Soil development is slow because of the long period each year when the land is frozen. For various reasons, notably the absence of earthworms, the humus layer on the surface is not mixed with the soil, but remains as a very black, highly acid accumulation. The lower part of the A horizon in mature podsols is leached to a gray or even white color. The B horizon is reddish from the accumulation of part of the leached material, and is very compact. These soils quickly lose their fertility under cultivation.

In parts of Group VI there is a permanently frozen subsoil. This is the case in the far northern part of European Russia, in Siberia east of the Yenisei, and in parts of Canada and Alaska—all regions of light snow cover and intense winter cold. This frozen subsoil, by prohibiting the percolation of water, is a further reason for the extensive development of swamps. Because the removal of the vegetation cover has in some places resulted in the thawing out of this ice, it is thought that perhaps this phenomenon has been inherited from the intense cold of the glacial epoch. It is known as *permafrost*.

The Occupance

The boreal forest lands rival the deserts in their scantiness of human inhabitants. Although these regions comprise 10 per cent of the world's land area, they are occupied by only about 1 per cent of the world's population. Furthermore, most of the inhabitants are recent comers

[1] A Russian word meaning "ash-colored underneath."

who have, for one reason or another, migrated to these more remote regions. The Asiatic steppe nomads, fleeing from the periodic droughts of the grassland regions, not only pushed westward into the forests of Europe and eastward into China but also northward into the taiga, where certain of the steppe tribes sought refuge from their warlike neighbors. More recently the Occidentals have extended their frontiers of settlement into these regions, and scattered outposts of Westerners are found in the most isolated places, supported by such extractive industries as mining, lumbering, fishing, and trapping.

OCCUPANCE BY NONOCCIDENTAL CULTURES

The several different tribes which were pushed northward into the Siberian taiga from the steppes of central Asia have readjusted their modes of life to this new environment in various ways. Some have given up their horses in favor of cattle; others, such as the Samoyeds of northwestern Siberia, have adopted the reindeer and have remained pastoral nomads. Perhaps the most adaptable of all these "native" peoples are the Yakuts, who occupy the basin of the Lena River, in the heart of the world's "cold pole." They have learned to supplement their cattle with fish and game, to raise agricultural products and sell them to the Russian settlements, and even to act as traders between the Russians and the more remote forest tribes along the Lena and its tributaries. The still more primitive peoples of the Canadian forests, who practice an economy of hunting and fishing only, are believed to have migrated from Asia through Siberia and Alaska into the New World at a time before mankind had advanced to the domestication of other animals than the dog.

Contacts with the European and American settlements or trading posts have seriously disorganized the native ways of living. In Siberia only the Yakuts are still increasing in numbers. In both Siberia and Canada the Occidental demand for furs has led to an increase of winter trapping. Men with their families start out into the wilderness in the fall and establish themselves in remote and isolated places, where they spend the winter in gathering a supply of pelts. With the melting of the snow in spring, when travel is limited to the rivers, they return to

Machetanz from Three Lions

FIG. 147. *Natives in Alaska replenish their larders in winter by fishing through the ice*

the trading posts and there exchange their skins for articles manufactured in the Occident, such as foods, rifles and ammunition, clothing, and strong drink.

OCCIDENTAL OCCUPANCE

This fur trade of the Europeans with the inhabitants of the taiga, both in Siberia and Canada, is now many centuries old. As early as the eleventh century the merchants of Russia were carrying on trade with the inhabitants of the Ob Valley. Trading posts were established during the sixteenth and seventeenth centuries, mostly at the mouths of the rivers down which the "natives" brought their loads of skins in the spring. The famous Hudson's Bay Company received its charter from King Charles II in 1670, and proceeded to locate posts first around the shores of James Bay and later along the western shore of Hudson Bay

Fig. 148. *Chief trading posts and routes of a portion of Canada*

(Fig. 148). For some time the Company did not find it necessary to penetrate inland, as the Indians brought their furs over great distances in order to purchase the white man's products. Competition with other fur-trading companies, however, forced the establishment of posts in the interior, mostly at important river junctions or at portages between river systems. Meanwhile the Russians had pushed their trading activities across Asia and into Alaska, and even southward along the Pacific coast to the Spanish settlements in California. Only the mountains separated them from the domains of the Hudson's Bay Company. Through the activities of these big trading companies vast areas of the boreal forest lands came under the control of two nations: Great Britain and Russia. In 1867 the United States purchased Alaska from Russia. Today railroad tentacles have been extended into these regions, and the posts at the railheads are the chief points of concentration of the fur traders.

Mining and Lumbering. Meanwhile other types of Occidental occupance have appeared which have done more to transform the landscapes of the forest lands than have the isolated trading posts or the activities of the trappers. These are the mining and lumbering settlements. Mining camps associated with the precious metals commonly grow with mushroom rapidity, and after a period of feverish existence are entirely abandoned. Furthermore, it is not much of an exaggeration to say that no place is too isolated or too remote from the developed means of transportation to prohibit the establishment of a mining settlement for the exploitation of such minerals as gold, platinum, and uranium, provided the ore bodies are sufficiently rich. Placer gold was exploited as early as 1830 in the territory just west of the mountains of central Asia between the headwaters of the Ob and the Yenisei. Other gold camps sprang into being, flourished, and declined. Today the chief centers of placer gold-mining in Siberia are located along the valley of the upper Lena and its tributary, the Vitim, northeast of Lake Baikal (Fig. 151). Placer gold, too, was the cause of the great gold rush of 1898 into Alaska. Auriferous gravels are widely distributed throughout the Yukon Valley and its tributaries (Fig. 153).

Somewhat more permanent are the mining settlements based on veins in the bedrock, such as the nickel, platinum, gold, and silver mines of the Sudbury-Cobalt Region of Canada. Most of the vein minerals, as in this case, are located in the upland areas of ancient crystalline rocks. Since prospecting must be done in summer, when travel away from the rivers is especially difficult, it is little wonder that the supposed mineral wealth of such regions as the Laurentian Upland of Canada should remain even today so little developed. The discovery of the ores at Sudbury in 1883 resulted from the digging of a cut along the new railroad line then being extended westward. Since the invention of methods for the use of uranium in atomic fission, this mineral, which is known to occur in several places in the Laurentian Upland, has been made the subject of widespread search. Where uranium ores have been found, large mining camps have been established.

Other mining regions require even closer connections with the industrial cities of Group IV. The iron mines of the Mesabi Range, west of Duluth, are very fortunately located at the end of one of the world's

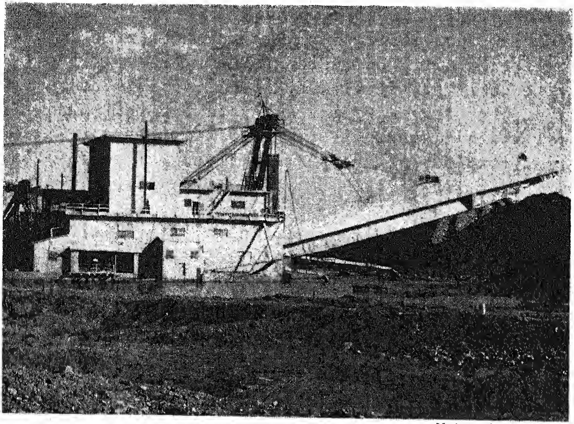
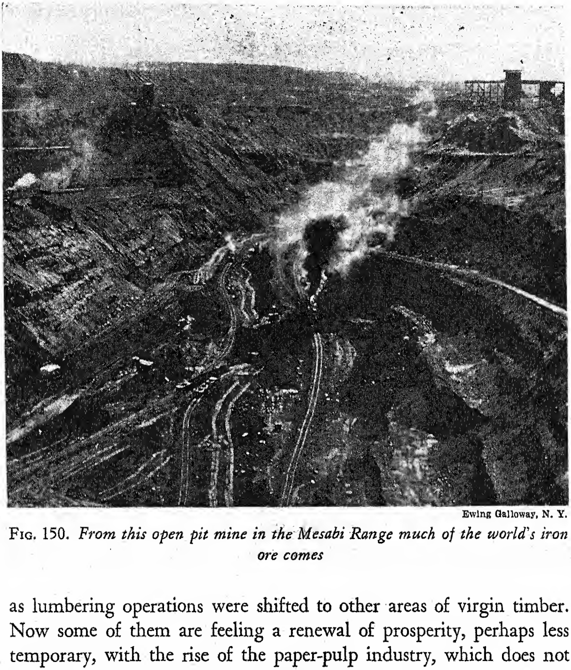

Machetanz from Three Lions

FIG. 149. *A gold dredge at work in a stream of the Yukon Plateau*

finest inland waterways, leading directly to the industrial cities farther south. The Kiruna iron district of Sweden (Fig. 193) is not so fortunately located, for a railroad line is necessary to connect the mines with Narvik, on the other side of the Scandinavian Highlands. Ore bodies in Siberia, including iron and coal, are at an even greater disadvantage. Although the rivers of this part of the world are navigable during the summer, they lead northward to an ocean which is open, if at all, for only a few months each year; in other words, these rivers are oriented, as is Lake Baikal, at right angles to the desired lines of travel. Yet coal fields are being worked along the line of the Trans-Siberian Railroad, chiefly south of Tomsk and west of Irkutsk (Fig. 151).

Lumbering operations in these regions are similar to mining in that they carry on the "destructive exploitation" of a resource which is not replenished. As the forests are cut over, the lumber camps must move on. Many are the towns of Canada, such as those along the northern shores of Lake Huron, which flourished for a time and then declined



Ewing Galloway, N. Y.

Fig. 150. *From this open pit mine in the Mesabi Range much of the world's iron ore comes*

as lumbering operations were shifted to other areas of virgin timber. Now some of them are feeling a renewal of prosperity, perhaps less temporary, with the rise of the paper-pulp industry, which does not require such high-grade stands of timber. The paper and match industries, utilizing the abundant water power, are of importance in the forests of Sweden and Finland. In northern European Russia the Soviet government is now establishing carefully planned lumbering settlements, supplemented by enough agriculture to make them self-supporting.[1]

[1]See the various studies of pioneer settlements in the boreal forest lands contained in *Pioneer Settlement*, Coöperative Studies, American Geographical Society, Special Publication No. 14 (New York, 1932); especially pages 236–239.

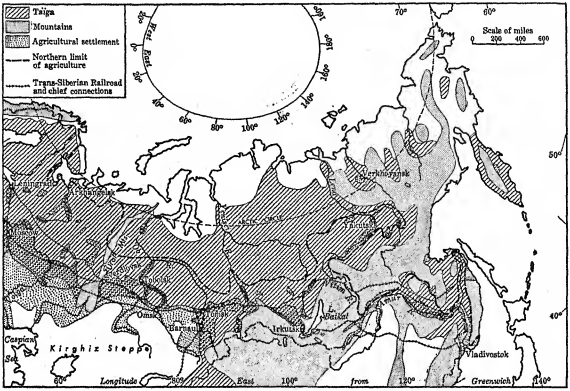


Fig. 151. *Occidental settlement in the northern U.S.S.R.* (After P. Camena d'Almeida)

Agricultural Settlement. Agricultural settlement in the boreal forest lands has been pushed far to the north, even beyond the arctic circle, yet the areas of such settlement are small and isolated. They represent inhabited islands in the midst of the thinly peopled forests. Like all Occidental pioneer settlements, they are located along the chief lines of travel—the navigable rivers or the rail tentacles.

The chief axis of settlement in Siberia is the Trans-Siberian Railroad (Fig. 151). This follows the black-earth belt of the grasslands until it enters the forest in the neighborhood of Tomsk. Clearings along this line in Group VI are scattered from Tomsk to Irkutsk, and beyond Lake Baikal in the valley of the Amur and its tributaries as far as Vladivostok. Penetration into the taiga to the north follows the valleys: along the Dvina nearly to Arkhangelsk, along the Ob to Tobolsk and beyond, and along the middle portion of the Lena to Yakutsk. Isolated spots of settlement are found in the valleys even within the arctic circle, the most northerly of these being Verkhoyansk.

In Canada the chief axes of settlement have been the St. Lawrence

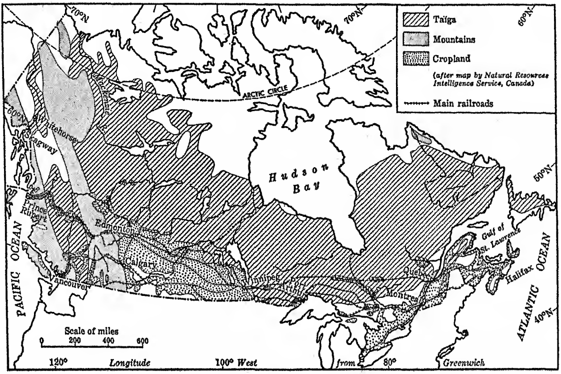


FIG. 152. *Cropland of Canada*

River in the east and the railroad lines across the grasslands beyond Winnipeg in the west (Fig. 152). Penetration of the forests to the north by agriculturists has been successful only in isolated localities. The occupance of the Laurentian Upland has been especially difficult, in spite of the proximity to the large cities along the St. Lawrence. Only in the Lake St. John lowland, and in the clay belts south of James Bay which have been opened up by the railroads, as around Cochrane, have agricultural settlements persisted. As in Finland and northern Sweden, this region seems little suited to agricultural occupance. The clearings north of Edmonton along the Peace River, however, are analogous to those of the Siberian taiga.

Agricultural settlement in Alaska has also been slow in developing. Although agricultural products of good quality have been raised at Fairbanks on the Tanana River (Fig. 153), the difficulty of reaching a market has proved very great. During the decade before World War II, a new pioneer colony was established in the Matanuska Valley around Palmer, along the railroad north of Seward and Anchorage.

Though the patterns of occupance on this northern pioneer fringe

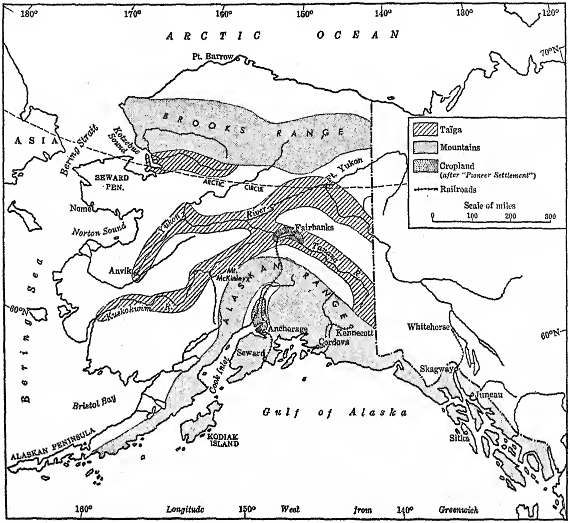


FIG. 153. *Cropland of Alaska*

resemble those of the early stages of Occidental settlement in the other forest lands of the world, it is not at all certain that they can be elaborated as the others have been. Agriculture is handicapped in the boreal forest lands in numerous ways. The severity of the winters, the shortness of the growing season, the isolated and spotty distribution of the areas of favorable soil, and the difficulty of reaching a market are all major obstacles to this form of occupance. As the climate becomes more rigorous toward the north the importance of the edaphic elements in limiting the areas of potential settlement becomes greater. In spite of the optimism expressed in some of the propaganda, there is considerable doubt as to whether these isolated forest clearings can ever be incorporated in the main area of Occidental settlement by the conquest of the

surrounding territory. This may be possible in certain areas along the southernmost margin of the taiga, but in most of the lands of Group VI widespread agricultural settlement under present conditions will probably not be feasible.

Animals and Crops. The pastoral and agricultural products which might support pioneer settlement in the boreal forests are numerous. Most important at present are the animals raised for meat or dairy. In terms of acreage the feed crops are more important than the food crops, and many of the grains are cut for hay and stored for winter feeding. Although cattle can scarcely compete for the large city markets in the regions of Group IV, they can be marketed in near-by lumbering or mining communities. Reindeer, however, might well compete with cattle raised in places closer to the markets. Reindeer do not need to be sheltered or fed on stored hay during the winters, for they can take care of themselves. Reindeer meat has actually been successfully sold in the United States, as it has been for a long time in the Scandinavian countries. It was so successful in the United States that a storm of protest from cattle-raisers was aroused. Stefansson[1] believes that the far northern pastures can, in fact, be developed to provide an important additional source of meat. But a pastoral economy supports only a small total number of people.

In a few parts of the regions of Group VI the production of spring wheat has provided economic support for settlement. The Peace River District of Canada, for instance, has been organized around the production of this grain, as have also the similar clearings in southwestern Siberia. An increase in the demand for wheat in the world markets would perhaps result in an extension of these wheat-growing communities; for wheat can be raised on favorable soils as far as the limit of ninety frost-free days and as far as the isotherm of 57° average temperature for the three summer months (Fig. 126). If suitable soils can be found, the temperature conditions would permit the development of wheatlands even north of the Peace River District and in certain small areas in Alaska (Fig. 153). However, wheat production

[1]Vilhjalmur Stefansson, "The Colonization of the Northern Lands," in *Climate and Man*, Yearbook of the U. S. Department of Agriculture, 1941, pp. 205–216.

in these areas must remain marginal both in the economic and in the geographic sense.

Beyond wheat other crops reach the farthest limits of agriculture. The hardiest of all the grains is barley; in the most northerly agricultural settlements of Siberia, Canada, and Alaska the usual crop combination is composed of barley, hay, and potatoes (Fig. 78). Vegetables and berries of rich flavor find suitable conditions of growth at these high latitudes and, with the establishment of canneries, might conceivably provide a commercial basis of settlement. Vegetable gardens are planted even on the delta of the Mackenzie River not far from the margins of the Arctic Ocean.

Conclusion

Man is still the intruder in these regions. Various cultures, driven by necessity to seek a refuge in the forests, have been able to maintain themselves, even if they have succeeded in doing little more than this. The Occidentals, in their search for the primary materials with which to fashion the structures and implements of their civilization, have established mining and lumbering centers even where all the necessary foodstuffs have had to be brought in from other regions. They have done the same in other parts of the world. These regions have now also been penetrated by the fringes of Occidental settlement. In especially favored places the isolated communities of pioneer farmers may prove permanent, but they are not likely to lose the flavor of the frontier for a long time.

GROUP VII

THE POLAR LANDS

Cold weather, even in summer; sparse vegetation or no vegetation at all; snow and ice visible in the landscape, at least in patches, throughout most of the year,—these are the outstanding characteristics of the polar lands. All these things can be experienced in one place or another, and at one time or another, in various parts of the world; but nowhere else, save on the poleward margins of the neighboring groups, can one find the long winter nights when the sun never comes above the horizon, or the long summer days when there is no darkness.

The polar night of the lower arctic latitudes, with its strange beauty, has been vividly described by the explorer Nansen:

> The sky is like an enormous cupola, blue at the zenith, shading down into green, and then into lilac and violet at the edges. Over the ice fields there are cold violet-blue shadows, with lighter pink tints where a ridge here and there catches the last reflection of the vanished day. Up in the blue of the cupola shine the stars, speaking peace, as they always do, those unchanging friends. In the south stands a large red-yellow moon, encircled by a yellow ring and light golden clouds floating on the blue background. Presently the aurora borealis shakes over the vault of heaven its veil of glittering silver—changing now to yellow, now to green, now to red. It spreads, it contracts again, in restless change; next it breaks into waving, many-folded bands of shining silver, over which shoot billows of glittering rays, and then the glory vanishes. Presently it shimmers in tongues of flame over the very zenith, and then again it shoots a bright ray up from the horizon, until the whole melts away in the moonlight, and it is as though one heard the sigh of a departing spirit. Here and there are left a few waving streamers of light, vague as a foreboding—they are the dust from the aurora's glittering cloak. But now it is growing again; new lightnings shoot up, and the endless game begins afresh. And all the time this utter stillness, impressive as the symphony of infinitude.[1]

How very different are these same scenes during the polar day! The colorful beauty of the night is lost in the white glare of the brilliant yet heatless sunshine. Instead of the awe-inspiring displays of light and shadow on white snow surfaces, the day brings pale skies, a horizon veiled in fogs, and a foreground of barren rocks and patches of ice or snow now pitilessly revealed in the daylight.

[1]F. Nansen, *Farthest North* (New York, 1898), pp. 252–253.

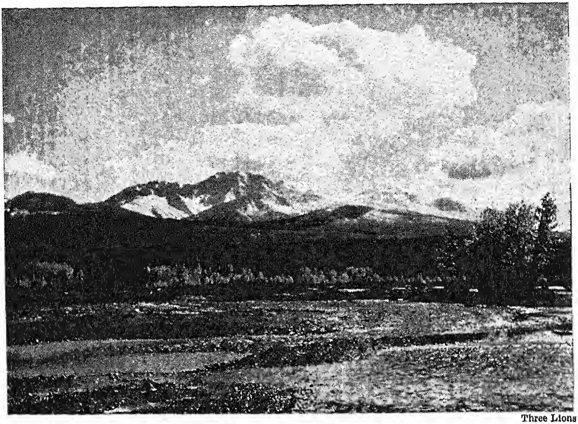


FIG. 154. *Near the northern limit of the taiga in Alaska*

For the whole twenty-four hours of the earth's revolution the sun circles the horizon, bringing real warmth only to the slopes which are steep enough to receive its rays nearly perpendicularly. In the shade, on the north-facing slopes at noon, or on the south-facing slopes at midnight, the air is cold. Bare ground appears from beneath the melting snow, and the ice on the polar seas breaks up in jumbled masses. In the far north sheltered places, warmed by the reflection from neighboring cliffs, are filled with a luxuriant cover of quick-flowering plants. Near the southern margins of the arctic regions, where the summer temperatures climb well above freezing, the land is covered with a mat of mosses, lichens, grasses, and flowering plants. Here only the surface thaws out, soaking this mat of vegetation like a sponge and providing breeding places for swarms of mosquitoes.

Except for the cool summers and cold, dark winters, the two polar regions of the earth are very different in character. The arctic is composed of a deep ocean basin, bounded by the northern coastal plains of

North America and Eurasia, with their fringes of island clusters. Just the opposite condition is found in the antarctic; for here there is a continent five million or so square miles in area, larger than Europe, which is bordered by the stormy Antarctic Ocean. Whereas the arctic shores are sparsely inhabited by men, the Antarctic Continent is totally uninhabited.

The Land

VEGETATION AND CLIMATE

In many respects the polar lands resemble the dry lands. Both are deserts in the sense of being largely uninhabited and also in the sense of possessing a meager cover of vegetation. The one is a desert of drought; the other, a desert of cold. Both of them, moreover, are bordered by a margin of semi-desert, a transition zone which separates them from the world's forest lands. Around the dry deserts are the grasslands of Group V; around the cold deserts are the tundras.[1]

As in the dry lands, there are few places in the polar lands which are entirely without vegetation. Glaciers present to the eye a glittering white surface without vegetation cover; and there are many areas of bare rock. But even the bare rock, on closer examination, usually proves to support mosses and lichens and scattered plants.

> Every Arctic traveller remembers his surprise and delight when for the first time in high latitudes he came on meadows of rich grasses, bright with tall, yellow buttercups, luxuriant saxifrages, violet cuckoo flowers, blue polemoniums, or many other flowers; moorlands purple with saxifrage as a Scottish hillside is with heather; peat bogs white with myriad tufts of waving cotton grass; dry banks with their hundreds of sturdy white and yellow poppies, clumps of red and yellow saxifrage, dryas, campions, and other blooms; or some wind-swept summit on which the Arctic poppy triumphantly flowered.[2]

The Tundra. The characteristic vegetation of the polar regions is the tundra; but the tundra itself, like the grasslands, is composed of

[1]For the convenience of classification the tundra and polar deserts are included together in one group, and the dry deserts and grasslands, with their varied modes of occupance, are placed in separate groups. There can be no argument for this except expediency.

[2]R. N. Rudmose-Brown, *The Polar Regions* (New York, 1927), p. 112.

transitional types. From the margins of the taiga, northward to the absolutely barren polar desert, three chief kinds of tundra are recognized: these are the *bush tundra*, the *grass tundra*, and the *desert tundra.*

The first of these is found on the edge of the taiga and in a few especially well-sheltered spots farther to the north. Here the flora is composed of dwarf trees, chiefly willow, birch, alder, and mountain ash. Where conditions are particularly favorable a scrub forest of birch is found, as in southernmost Greenland; but mostly the tallest individuals rise no more than three feet above the ground. The bush tundra grades off rapidly into the broader zone of the grass tundra, which is composed of a nearly continuous mat of sedges, mosses, and lichens, mixed with bushes which lie prone on the ground. This grass tundra, like the other polar types, rests on a permanently frozen regolith; and when the surface thaws out during the summer the water does not drain away, but is soaked up by the spongy vegetation. Summer travel over these tundras is described by the expressive term *mushing*. Still farther poleward the grass tundra breaks up into detached "oases" in the sheltered hollows, separated by expanses of bare rock or regolith. This is the desert tundra (Fig. 155).

The Animals of the Polar Lands. In view of the severity of the polar winter the richness and variety of the fauna of the arctic regions are remarkable. Many of the land animals of the taiga migrate northward onto the tundra during the summer months. The reindeer of Eurasia and the similar, but smaller, caribou of North America are the most important of these. Another large herbivore found far within the arctic is the musk ox, or ovibos, generally now surviving only in isolated herds which graze on the more luxuriant patches of desert tundra. Two small herbivora—the arctic hare and the lemming—are also widespread in the arctic.

Following the herds of reindeer, caribou, or musk ox are a number of predatory animals, such as the wolf and fox. Most of these carnivora, however, belong typically to the taiga fauna and are intruders in the polar lands. The drift ice of the polar sea or the immediate coastal margin is the habitat of the polar bear, which preys chiefly on marine life—the seal and the walrus.


McCracken from Three Lions

Fig. 155. *Bear hunters on the grass tundra in Alaska*

Birds and insects are particularly numerous. Mosquitoes are probably present in greater numbers in summer over the tundra than anywhere else on earth and are a terrible plague to the human and animal inhabitants, although not as carriers of disease. Bees and butterflies perform their usual function of the fertilization of flowers. Flies are abundant, especially near human habitations. Attracted in part by this abundance of insect life, many a migrating bird in summer makes the tundra its goal. The rocky shores of the arctic seas provide breeding places for a great number of the birds well known in middle and even low latitudes. The land birds which remain in the regions during the winter include the ptarmigan, the snowy owl, the gerfalcon, the raven, and the snow bunting.

Sea life is rich. Although reptiles, amphibians, and fresh-water fish are either entirely absent or very rare, the inhabitants of the polar

oceans are varied and numerous. The seal, the walrus, the whale, the narwhal, and the sea elephant are among the most typical forms of sea life.

In the antarctic regions a land fauna is practically nonexistent, although the sea life is abundant. The largest known land animal on the Antarctic Continent is a wingless mosquito, found in only one single protected locality. There are no land mammals; no land birds. Because of the absence of predatory animals, the penguins find conditions on the coasts and on the isolated islands of the Antarctic Ocean ideal as breeding places. These birds, unable to fly and awkward on the land, could scarcely exist in the presence of a land enemy.

The Polar Climates. These various zones of vegetation with their associated faunas correspond closely to the summer temperatures. All the polar climates average less than 50° in the warmest month. In the Northern Hemisphere this isotherm corresponds closely to the boundary between the taiga and the tundra. The continuous vegetation cover of the bush and grass tundras is found mostly within the regions which have warmest-month temperatures between 50° and 41° (Fig. 156). Where the temperatures drop below 41° in the warmest month, only the desert tundra can exist. The polar desert, including the areas covered by ice, corresponds with the places where the warmest month averages below 32° (in the Northern Hemisphere only Greenland and possibly a portion of Ellesmere Island).

In the Southern Hemisphere very little of the Antarctic Continent extends far enough northward to reach the isotherm of 32°. Only in these few places is any vegetation found (Fig. 157). A very peculiar type of polar climate exists in southernmost South America and some of the islands of the Antarctic Ocean. Here, although the warmest month averages under 50°, the coldest month is over 32°. This is an extreme of marine conditions—the result of great expanses of open sea. Tierra del Fuego, in spite of its position with reference to the isotherm of 50° for the warmest month, is covered by a broadleaf forest, mostly of antarctic beech.

The polar climates are not necessarily colder in winter than are the climates of higher middle latitudes. The lowest air temperature ever

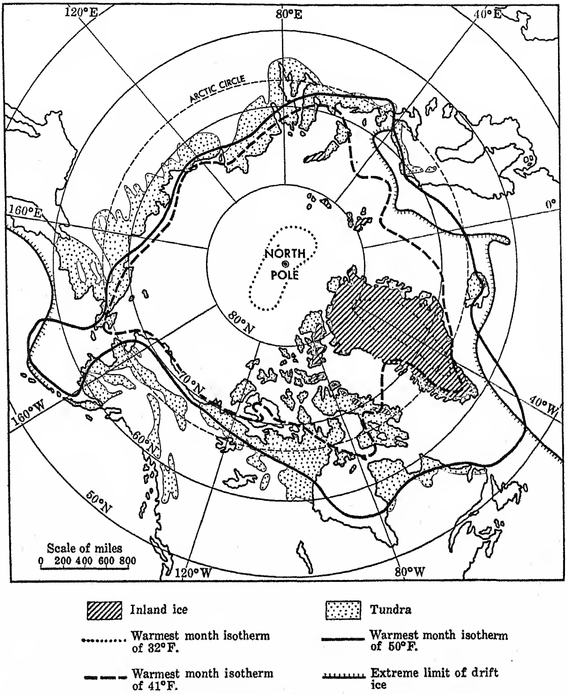
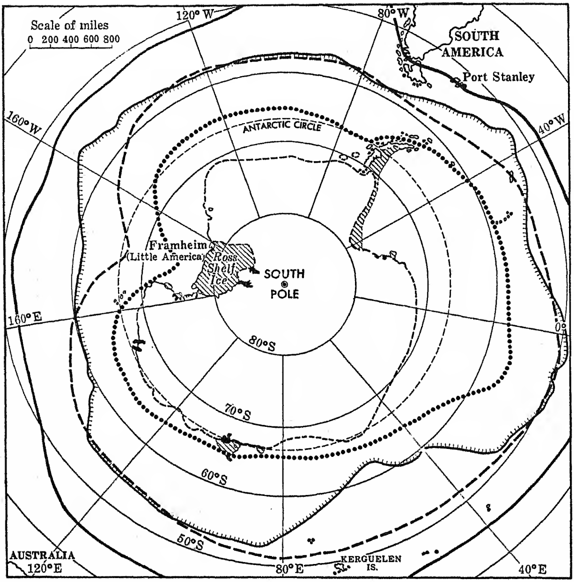


FIG. 156. *The north polar regions.* (After Nordenskjöld and Mecking)

recorded at the surface of the earth was observed in northeast Siberia about on the arctic circle. Most of the polar regions are known to experience winter temperatures considerably more moderate than this. It is possible, however, that winter observations in the interiors of the high ice plateaus of Greenland and Antarctica might give readings



Known shelf ice — Known valley and piedmont glaciers

Known / Postulated } Coast line

Warmest month isotherm of 32°F. — Warmest month isotherm of 50°F.

Warmest month isotherm of 41°F. — Extreme limit of drift ice

(The extent of ice cap which covers most of the continent is largely unknown)

FIG. 157. *The south polar regions.* (After Nordenskjöld and Mecking)

even lower than Verkhoyansk. From both Greenland and Antarctica, especially the latter, come great outblasts of cold air which move at high velocities and blow along great quantities of snow. Mawson names the Antarctic Continent "the home of the blizzard." The neighboring oceans in the higher middle latitudes of the Southern Hemisphere are among the stormiest in the world.

SURFACE FEATURES

The surface features of the polar lands include all varieties of relief, from low, swampy coastal plains to high ice plateaus and glaciated mountains. In the Northern Hemisphere the Arctic Ocean is bordered for the most part by the Eurasian and North American coastal plains (Plates 9 and 17). These lowlands are interrupted by the Urals, a chain of low mountains which extends into the polar ocean through Novaya Zemlya, and by the highlands of Greenland and the neighboring islands. Part of the Canadian arctic archipelago is composed of low-lying detached pieces of the North American coastal plain, underlain by horizontal stratified rocks; but the easternmost coasts which face Greenland, notably of Ellesmere and Baffin islands and of Labrador, stand up as ice-scoured hills and low mountains still partly covered by glaciers. The ice-free coasts of Greenland are similarly composed of heavily glaciated uplands. Iceland and Svalbard are also mountainous and harbor small accumulations of ice. But none of these existing glaciers is so extensive as the inland ice which masks the greater part of Greenland (Fig. 158). In the Southern Hemisphere the continent of Antarctica is covered by the world's largest existing icecap.

Landforms. In contrast to surfaces exposed to a tropical rainy climate, which are attacked dominantly by chemical decomposition and are speedily covered by a thick mantle of fine-textured regolith, the surfaces in the polar regions are attacked dominantly by physical disintegration, the exposed rock being shattered and broken into angular fragments by frost action. Nowhere else, except on the summits of high mountains above the timber lines, is frost action so potent a force in fracturing the rock surfaces. The lower slopes of cliffs broken up in this way are covered with accumulations of rock fragments, much as

in the deserts. Plateau surfaces not covered with ice are mantled with angular blocks of rock loosened by frost action, forming a very rough surface known as a *rock field*. In the course of time such rock fields may be modified by continued frost action until a coarse, gravelly regolith is produced.

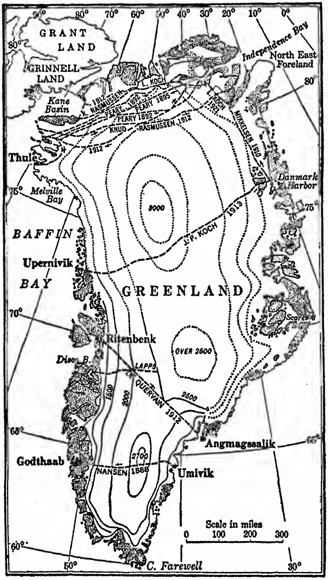
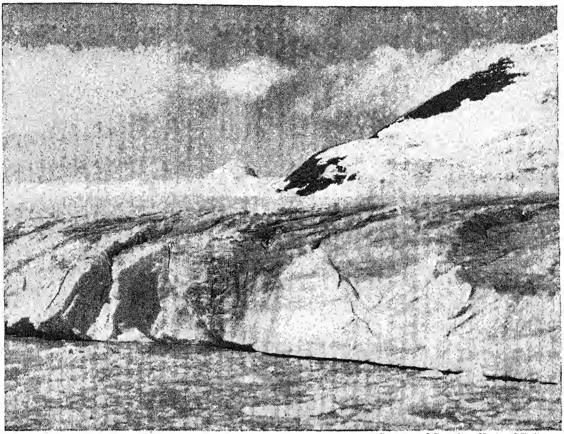


FIG. 158. *Greenland, showing the configuration of the inland ice (elevations in meters), the ice-free areas (stippled), and the routes followed by explorers crossing the inland ice.* (After De Quervain: courtesy of the *Geographical Review*, published by the American Geographical Society of New York)

Erosion is carried on by processes very different from those of the rainy lands. Even more than in the case of the dry lands running water is limited to the exotic rivers. River valleys exist, to be sure, along the courses of the north-flowing rivers of Canada and Siberia. Except for summer streams pouring from the front of melting glaciers, however, other streams in the polar regions are poorly developed. As a result the water from the melting snow and ice during the arctic summer forms extensive ponds and marshes on the surface.

Glacial erosion is at a maximum. Where the formerly more extensive glaciers of the ice age passed through mountain valleys they produced typical glacial troughs. Near the coast, where the valleys were deepened below sea level by ice scour, the drowned glacial troughs are known as *fiords*. However, while the ice had the effect of smoothing



Courtesy of Canadian National Railways

FIG. 159. *Along the course of one of the north-flowing rivers in British Columbia*

the hills and deepening the valleys, it seems to have had little effect on high-level plateaus; in fact, it seems to have preserved them from weathering. The high-level surfaces of Labrador and Norway are little touched by erosion; instead, they are mantled with rock fields apparently of postglacial origin.

Along the coasts a feature common in the polar regions is the *strand flat.* This is a marine terrace bordered on the landward side by an abrupt sea cliff and extending seaward in a fringe of rounded, polished islets known as *skerries.* In some places the strand flat broadens out to ten or twelve miles in width; in other places it may be very narrow or entirely lacking. The flat-topped rock ledges and the partially submerged skerries are persistent elements of the arctic coastal landscapes of the hilly or mountainous sections.

In addition to the landforms produced by glacial action, there are also vast lowlands which were never ice-covered (Fig. 143). These are monotonously flat and poorly drained.

Machetanz from Three Lions

FIG. 160. *Eskimo girls dressed in their fancy parkees*

The Occupance

Man in the polar regions maintains his existence only by continuous effort. Along with the driest deserts, these regions are among the world's least favorable habitats; and along with the deserts, the polar lands have been the least penetrated by Occidental settlement. Two chief native cultures are found in the high latitudes of the Northern Hemisphere, and the patterns of population distribution developed by these contrasted modes of occupance are quite distinct. The Eskimos, chiefly of North America, are the only people who have established themselves permanently in the arctic lands. Since their occupance is based on the hunting of the seal they are nomadic or seminomadic, and they never place their villages far from the seacoast. On the other hand, the Eurasian tribes, whose occupance is based on the domesticated reindeer, are pastoral nomads, living on the tundras only during the sum-

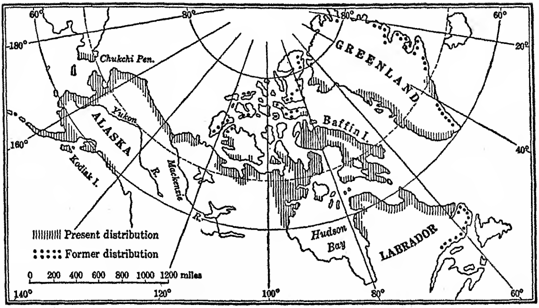


Fig. 161. *The maximum distribution of the Eskimo culture, with an indication of the lands from which the Eskimos have withdrawn.* (From Ludwig Mecking, *Die Polarländer*, Leipzig, 1925)

mers and seeking refuge in the forests during the winter months. Their summer villages are placed back from the coast. Occidental contacts with these peoples have been largely through the activities of traders, explorers, and missionaries, and have resulted only in a modification of the native way of living, not in the establishment of many permanent European or American settlements.

The population of the polar regions is entirely limited to the Northern Hemisphere. The great Antarctic Continent is surrounded by a stormy, ice-filled ocean which has so effectively barred the access of man that until the airplane could be used for exploration large parts of its coast were unknown.

OCCUPANCE BY THE ESKIMO CULTURE

The Eskimos occupy the margins of the polar seas from the extreme northeast of Siberia across northern North America to eastern Greenland and Labrador. Their present distribution, and the whole territory over which the signs of Eskimo occupance have been found, are shown on the map (Fig. 161). Over these many miles of arctic coast there are

probably not more than 33,000 Eskimos, and of these probably 14,500 live in Greenland.[1]

The Eskimo culture represents an amazing adaptation to the harsh conditions of arctic living. Agriculture is entirely lacking, and very few of the products of the plant world are utilized in any way. The seal provides the basic support; from this animal come clothing, food, implements, and even fuel. Only a very few small tribes of Eskimos live inland and depend on the migrations of the caribou. Hunting is a serious business; for, in spite of a high degree of skill and almost continuous effort, game is not always plentiful and starvation is the consequence of failure. The best season of the year for seal-hunting is the winter, except for the darkest period in December. The surface of the polar sea is frozen, and travel long distances by dog sled is relatively easy. The Eskimos have learned that if the nearer hunting grounds are visited too frequently the game will be driven away; during the winter, therefore, they frequently travel for weeks at a time to distant places where seals are reported to be plentiful.

The seal, however, must be supplemented with other game. Numerous sea animals are hunted during the summer with the aid of the kayak, or skin boat. At this season also the large land animals, especially the caribou and the musk ox, are sought; for although their meat is less satisfactory than that of the seal or the walrus, owing to the small amount of fat it contains, nevertheless it provides a pleasant variety and a much needed supplementary supply to be "cached" as a provision against later want. Birds and birds' eggs are also much prized as offering a change in the steady diet of seal. Yet throughout the year the Eskimos eat little else but meat: meat eaten cooked but more often raw, or frozen, or rotten; meat served without salt.

Eskimo Settlements. The nomadic or seminomadic type of life is essential in such a culture. Migrations of the game are closely followed by migrations of people. Only where water and ice conditions are especially favorable for the seal—so favorable that a dependable supply is certain year after year—can the Eskimos become in any way sedentary. Even the land animals have been the cause of migrations. At

[1] R. N. Rudmose-Brown, op. cit. p. 145.

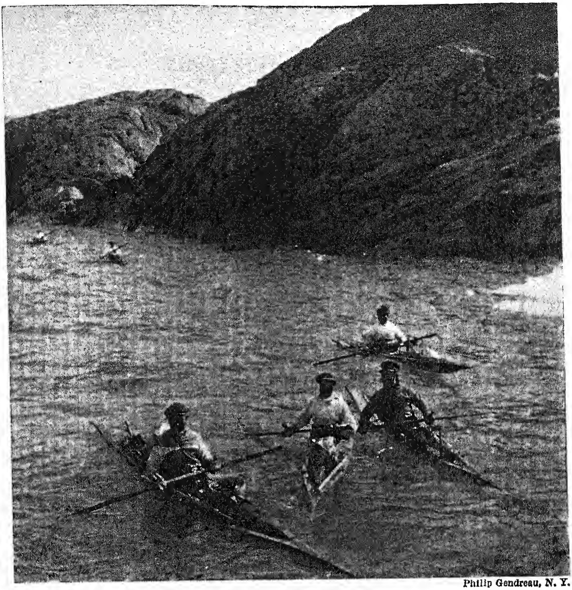


FIG. 162. *Eskimos in their kayaks along the coast of Labrador*

the present time the absence of both sea and land game from the outermost islands of the Canadian arctic archipelago is reflected in the absence of Eskimos in this region.

Yet the Eskimos are not without attachment to certain sites. During the winter they gather together in villages near the water known to be frequented by seals.[1] The immediate locations of these villages de-

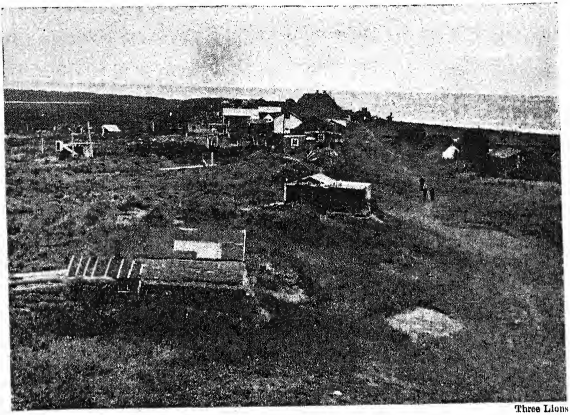
[1]See the description of the life of the "Polar Eskimo," the nothernmost of the world's human inhabitants, who occupy the peninsula of Thule in western Greenland north of latitude 76° N., in W. Elmer Ekblaw, "The Material Response of the Polar Eskimo to Their Far Arctic Environment," *Annals of the Association of American Geographers*, Vol. 17 (1927), pp. 147–198, and Vol. 18 (1928), pp. 1–24.

pend on such features as ease of approach over the sea ice, protection from high winds, supplies of drinking water (usually from stranded icebergs), and other local factors. In all the centuries during which the Eskimos have occupied the shores of the polar seas, they have returned to these same places again and again. The stone houses used during the winter were first built before the memory of the oldest inhabitants; they have been repeatedly abandoned and reoccupied. The movements of these people, therefore, are between points more or less definitely fixed.

During the summer the Eskimo becomes more completely nomadic. With his skin tent he travels along the coast to visit the summer sealing grounds or the cliffs on which great numbers of birds breed. Small groups, too, travel inland to hunt the caribou and the musk ox, so that at this season the distribution of people is less rigidly attached to the coast or to any particular sites.

Contacts with the Occidentals. Contacts with Europeans and Americans have not been fortunate for the Eskimos. In a region where such a delicate balance has been established between the occupance and the resources, the introduction of different ways of living, and especially of different weapons, could not fail to make necessary some fundamental readjustments. For example, the rifle made the pursuit of game much simpler and more certain. But, far from benefiting the Eskimo, this weapon has only resulted in such a rapid elimination of the game that the occupance of great stretches of the arctic coast has become impossible. The Eskimos have been forced to gather together in settlements near the white man's trading posts or mission stations. Lacking a profitable product, their lot is indeed miserable, and their misery is increased by sickness, for the white man's diseases are even more deadly than his weapons. The Eskimos, living in a land relatively free from the bacteria of the mid-latitude and tropical maladies, have built no immunity to them. Epidemics of smallpox, influenza, and other diseases have startlingly reduced the Eskimo population.

This destruction of native cultures by the most remote contacts with Western peoples is a phenomenon which has been described in these pages from examples in many different parts of the world. Where the natives could find resources to tempt the white man's markets, such as



Three Lions

FIG. 163. *Native sod dwellings north of the arctic circle in Canada*

ivory or ebony from the tropical forests, or dates from the desert oases, or furs from the taiga, they could adjust their ways of living to the demands of the Occidental trading posts. But the Eskimos have little to offer.[1] Recently an attempt has been made to introduce reindeer among the Alaskan Eskimos and to send the meat to the Occidental urban markets. Except for some such complete transformation of the Eskimo way of living, these interesting people, once so nicely adjusted to the region, seem doomed to perish.

OCCUPANCE BY THE EURASIAN CULTURES

Probably the whole Eurasian tundra does not support more than thirty thousand people, and during the winter the population is much less than this. The various peoples of the taiga, chiefly the Samoyeds

[1]The seal which is found in the regions inhabited by the Eskimos is the "hair seal," which is of limited commercial value. The "fur seal" (*Callorhinus alascanus*) is a pelagic animal, coming to protected islands only to breed. At the present time the largest herd of fur seals breeds on the Pribilof Islands, off Alaska.

and the Chukchi, who have domesticated the reindeer, migrate northward with these animals during the summer, much as the wild herds of reindeer used to migrate and as the caribou of North America still migrate. These nomadic peoples have no permanent villages, either in summer or in winter, but move their herds from place to place to take advantage of the slow-growing pasturage. When the snow begins to fly, they move into the taiga and abandon their skin tents in favor of pits dug in the ground. These Siberian tribes are therefore only partly dependent on the polar habitat. Their diet of meat is supplemented by fish from the rivers and by berries, roots, and nuts from the forest. Furthermore, the possession of domestic animals frees them from the fortunes of the chase. They are not so close to the margin of existence as are the Eskimos, nor are they so harmoniously adjusted to the conditions of arctic living.

Contacts with the European traders have been as detrimental to most of these peoples as in the case of the Eskimos. Among all the Siberian forest and tundra tribes, only the Yakuts are increasing in number. Apparently none of these cultures can survive except in greatly modified form—perhaps organized for the production of a meat surplus from the reindeer herds in exchange for which the white man's industrial and agricultural products can be purchased.

OCCIDENTAL OCCUPANCE

There is little to record concerning the occupance of the polar regions by Europeans and Americans. While these regions have attracted parties of explorers since classical antiquity, little permanent settlement by white men has ever taken place. The trading posts, which are the only permanently inhabited spots along the Eurasian arctic littoral, are engaged in the handling of the products of the taiga (chiefly furs) and are located at the mouths of the north-flowing rivers. A number of similar posts in North America have been established within the polar lands, but they are not supported by polar products.

Whaling and mining have also attracted Occidentals to these regions and have led to the establishment of settlements. The whaling industry, so important before the days of mineral oil, shifted from the vicinity of


Three Lions

Fig. 164. *Natives cutting up a white whale for food for their dogs*

Svalbard to the more remote parts of the world as the whales were killed in increasing numbers. Modern mechanical equipment threatens the final exhaustion of this resource. Until recently the whaling industry required land bases for the extraction of the oil, and such bases were established where protected harbors provided shelter for the whaling fleet. A number of these stations were located in the arctic, as at Herschel Island off the mouth of the Mackenzie River, and in the antarctic, as at Stanley, on the Falkland Islands. With the invention of the modern whaling ships, which are, in reality, floating packing plants where the carcasses are turned into a variety of products, the land stations have declined in importance.

Mining too has supported more or less permanent settlement in a

few localities in the north. The coal mines of Svalbard are perhaps the most important, although gold in Alaska continues to provide a somewhat unsteady basis for such communities as Nome.

The immediate future gives promise of considerable development of air travel. The air routes between North America and Europe cross parts of the polar regions, especially Greenland and Iceland. The air routes between North America and east Asia cross Alaska. Permanent fueling stations with small colonies of attendants have added another form of Occidental settlement within these regions.

Conclusion

The Occidental peoples have not yet found a resource by which permanent polar settlement can "pay its way." Hitherto occupance has been based on resources of other regions seeking an outlet through the arctic, or on temporary extractive industries, such as whaling and mining. Agriculture being physically impossible, permanent settlement would have to rest on pastoral activities, probably those associated with the reindeer. But the permanence of the arctic pastures under heavy grazing has yet to be demonstrated. The native cultures, so intimately adapted to the region, have been disorganized by the introduction of Occidental tools and foods, and are threatened with annihilation. On the whole the landscapes of the polar lands have been modified by human occupance to a lesser degree than those of any other group.

GROUP VIII

THE MOUNTAIN LANDS

Most people think they know what a mountain is. Yet when we compare such relatively small and inconspicuous features as the Turtle Mountains of North Dakota with such imposing heights as the Berkshire Hills of Massachusetts, we find that we cannot depend on popular impression and terminology for our definition of mountains. The dictionary says that a mountain must rise to sufficient elevation and with sufficient abruptness to stand out conspicuously from its surroundings; also that it must have a relatively small summit area, as opposed to a plateau, which has a large summit area. This definition admits of considerable range of interpretation, for the feature which would stand out conspicuously on the plains of North Dakota would remain quite incidental in a hilly land such as New England. Nor is elevation above sea level a safe guide to the definition; for there are many examples of mountainous surfaces at low elevations, and many plains which rise gradually to high elevations. As a matter of fact, any definition must be arbitrary because no sharp distinction exists in nature between high hills and low mountains. There is a complete series of steps from almost featureless plains to plains with many steep slopes but of slight relief, to low hills, to high hills, to low mountains, and finally to the highest mountains. Only in certain places do mountain fronts stand imposingly above extensive plains. For the purposes of classification in this book we have adopted as a working definition of "conspicuous" the concept that the elevation must be sufficient to bring about a vertical differentiation of the vegetation cover. We shall explain this definition and its limitations more fully as we proceed.

The mountain lands differ from the other seven landscape groups in several important ways. In the first place, the chief criterion for the recognition of mountain areas is the surface configuration, whereas the other groups are recognized primarily by the various kinds of vegetation. The characteristic features of mountain landscapes are associated with ruggedness of terrain. According to the definition we have adopted for mountains, vertical differentiation of vegetation types

is an essential characteristic. The occupance also is commonly arranged in layers. In other words, the major landscape differences are found in Group VIII by ascending or descending the slopes; not, as in the other groups, by traveling horizontally north, south, east, or west. Another characteristic of mountain geography is the intricacy of the patterns of distribution as compared with the relative simplicity of the patterns developed on more level lands. To follow the winding course of an isarithm, for example, through the valleys and around the ridges of a mountain region requires a much larger-scale map than is necessary in order to observe the same degree of accuracy in plotting the relatively simple course of the isarithm on a level surface. Unlike the monotonously similar landscapes over large areas on the plains, the mountain landscapes are spotty; they are arranged in a mosaic of small units, each contrasted sharply with the surroundings, resembling the patterns on a crazy quilt. Still another characteristic of mountain lands is the difficulty of moving over their rugged surfaces or steep slopes. As a result these regions are isolated and offer places of refuge for the survival of relict flora or fauna or even cultures; they are areas of survival of ancient ideas and modes of life, not areas where new ideas originate. As a further result of the difficulty of movement over them, mountains play the role of barriers to the spread over the earth of plants, animals, and man. Mountains cover 12 per cent of the earth's land area, and of the world's population about 12 per cent occupies the regions of this group.

Distribution of Mountains. Mountains are major lineaments of the face of the earth, and their distribution controls even the shape of the several continents. The essential features of mountain distribution have already been described (Fig. 1). From the central knot in southeastern Asia the world's high mountains extend in three directions: southeastward through the East Indies to New Zealand; northeastward and around the northern and eastern margins of the Pacific Ocean to the southern end of South America; and westward through southern Asia, southern Europe, and northern Africa to the Atlantic. Only a few more or less isolated mountain areas exist which are not attached to this basic system (Plates 9–19). We may now turn to an examination of the characteristics of these regions.

The Land

SURFACE FEATURES

Of fundamental importance in producing the intricacy of the distribution patterns in mountain regions are the surface features. Mountain surfaces are of the greatest variety not only in their topographic details but also in their broader aspects. Nevertheless, in spite of this variety, certain characteristic designs are repeated in almost all the world's high-mountain regions. For example, there is a tendency for the ranges to take on an arcuate, or festoon, arrangement. Commonly, also, the mountain arcs are backed on their concave sides by more or less extensive tectonic basins; and off the middle of the convex sides there are usually rift depressions, in many cases ocean "deeps."[1] With few exceptions, too, the distribution of volcanoes coincides with that of the ranges of high mountains (Fig. 165).[2]

These general patterns, characteristic of all mountain regions, are the result of certain basic similarities of geologic origin. By pressures and strains developed in the earth's crust, the rocks are crushed, folded, wrinkled, broken, and pushed up along certain zones of crustal weakness. These zones of weakness form the three-line figure described above. The various kinds of structures, or tectonic forms, developed in these zones are described briefly in Appendix C, and are made the subject of more intensive study in courses in geology.

As soon as rock structures are lifted above the sea they are exposed to the various processes of destruction or denudation (see Appendix C). Exposure to the weather results in the breaking of the surface of the rock into fragments, so that eventually a mantle of loose rock debris is formed which we have previously described as a regolith and on the surface of which soils form. Rain falling on the sloping surfaces of

[1]These various tectonic features have their geological explanations. See, for example, W. H. Hobbs, *Earth Evolution and Its Facial Expression* (New York, 1921), pp. 135–158.

[2]Ocean deeps in Fig. 165 based on Sir John Murry (and Dr. Johan Hjort), *The Depths of the Ocean* (London, 1912), map II. Volcanic areas based on Joseph P. Iddings, *The Problem of Volcanism* (New Haven, 1914), map. Earthquake regions based on F. de Montessus de Ballore, *Les Tremblements de terre: géographie séismologique* (Paris, 1906), maps I and II.

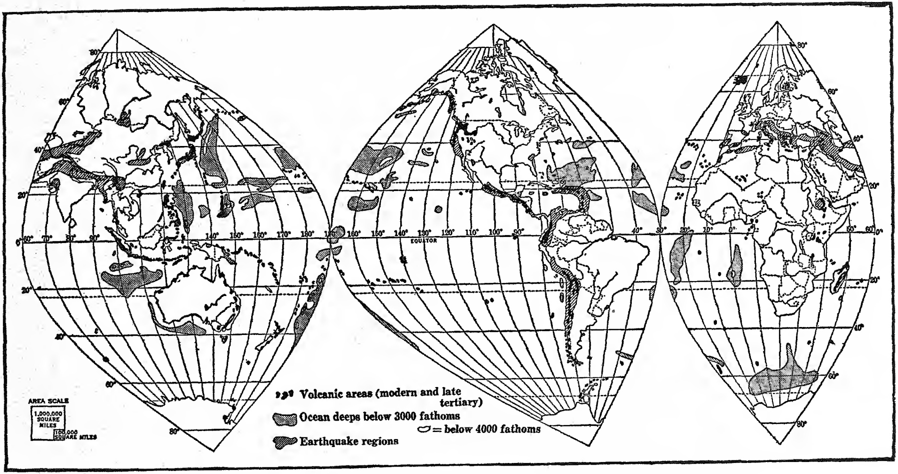


Fig. 165. *Areas of volcanic activity, ocean deeps, and earthquake regions of the world*

upraised areas runs off over the surface and forms rills, gullies, valleys, and canyons; furthermore, as the rivers continue over long periods of time to carve the upraised surfaces, the valleys pass through a sequence of stages to which William Morris Davis gave the descriptive terms: youthful, mature, and old. The youthful valleys are V-shaped, and the rivers which pass through them are torrential. When the valley bottoms have been cut down almost to the level of the body of water into which the stream flows they cannot be lowered any more, and the stream expends its energy in widening the valleys; the valleys with flat bottoms but steep sides are said to be mature, a stage in which there is the maximum amount of relief. After very long periods of time the intervening heights between the valleys, the interfluves, are also worn down, and the rivers meander freely across wide floodplains; this is the stage of old age (see Fig. 228 in Appendix C). The most important process of denudation which produces the landforms in upraised portion of the earth is that of running water.

There are many other processes, however, which produce strongly marked surface features in places where they have been in operation. Glaciers form on high mountains wherever the snowfall of winter is so deep that it does not all melt off during the summer. They are therefore most common in climates which have heavy precipitation and cool summers. The climates of higher middle latitudes on the continental west coasts fill this description most fully, and in these regions glacial landforms are most conspicuous; but even on the equator, if one climbs high enough, one finds the mountaintops permanently covered with snow. The various landforms produced in mountain areas as a result of glaciation are shown in a series of block diagrams in Appendix C (Fig. 234). Since the ice was everywhere more extensive in the Ice Age, these various forms are to be observed where glaciers no longer exist. The places where mountains or mountainous escarpments border the sea, and where the ice-deepened valleys are drowned, are today clearly visible, even on small-scale maps, as fiorded coasts. The map of a part of the coast of South Chile (Fig. 166) illustrates this feature. Similar coasts are to be observed in British Columbia and South Alaska, in Norway, in Labrador, and in New Zealand. Glacial landforms in the interior are similar to those near

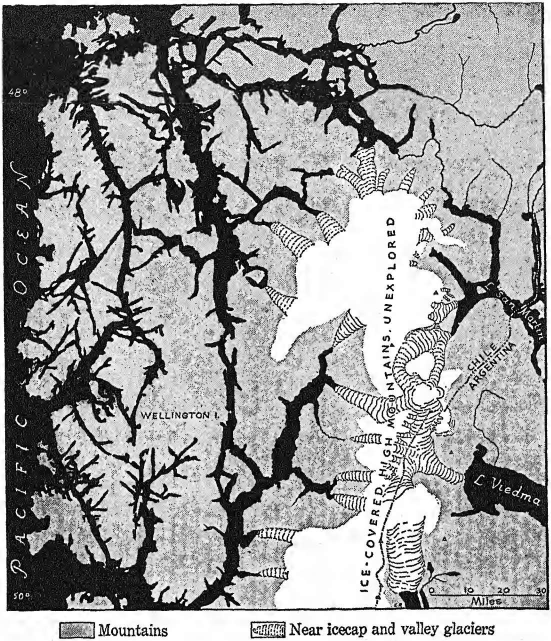


FIG. 166. *A near icecap in the southern Andes with detail of the fiorded coast of South Chile.* (From the Map of Hispanic America, published by the American Geographical Society of New York)

the coast except that more of the valley bottoms and sides are visible. Long, narrow marginal lakes, however, are commonly found along the edges of glaciated mountains, such as those of the Italian piedmont, or the eastern front of the Rocky Mountains in Montana (Glacier National Park). Some of the world's most spectacular mountain scenery is to be found where glaciers have had a chance to sculpture the surface.

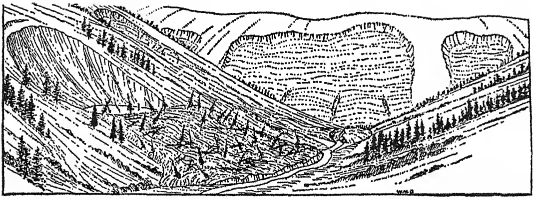


FIG. 167. *Landforms produced by landslides*[1]

Of the other processes of denudation which work on the sloping land of mountainous areas we need only mention the work of gravity which produces rock slides and avalanches. In mountain regions where steep valley slopes are subjected to soaking and drying with the passing seasons, avalanches are common, and the scars of ancient slides are to be observed in many places. The characteristic landforms produced by recent and older slides are suggested in the accompanying drawing (Fig. 167).

All these many kinds of landforms are infinitely varied by the underlying rock structures. In some mountain areas the structures are produced by simple folding (as in the case of the Jura Mountains, shown in the upper cross section of Figure 168). Most high mountain regions, however, are more complex than this. The Alps, for example, are tightly folded and faulted (as shown in the lower cross section of Figure 168). Other mountain regions are formed by block faulting, in which large masses or blocks of the earth's crust are broken and lifted or dropped in relation to bordering blocks. Rocks, therefore, are broken and contorted into very complex structures, and in many places these structures are masked by a covering of volcanic material—old lava flows or deep accumulations of ash. Each kind of rock formation differs in its resistance to the forces of denudation. Some rocks are weak and easily eroded; others are resistant. As the processes of denudation work on the underlying structures the work goes forward rapidly on weak rocks, whereas resistant rocks stand out boldly as cliffs

[1]Reproduced from a drawing in W. M. Davis, "The Lakes of California," *California Journal of Mines and Geology*, Vol. 29 (1933), pp. 175–236.

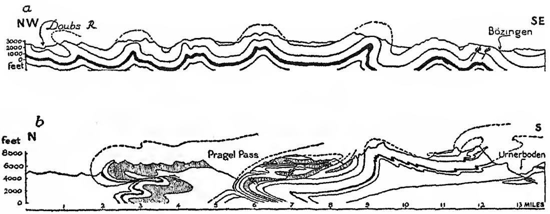


FIG. 168. (a) *Cross section of the Jura Mountains;* (b) *cross section of the Alps*[1]

or still uneroded heights. The result is the extraordinary complexity of mountain terrain.

In many of the mountain regions of the world, areas which are nearly flat or gently sloping occur in the midst of steeper and higher surfaces. These are intermont basins, which are distinguished on the plates (Plates 9–19) by solid black. The accompanying block diagram suggests two ways in which intermont basins can form (Fig. 169): on the left where a downfold of the rock structures forms a basin; on the right where a depression between two mountain blocks is partly filled with alluvial material washed down from the higher slopes. Intermont basins are formed upstream from places where the rivers pass through resistant rock formations and where, as a consequence, the downward cutting of the valley is retarded. They are formed where volcanoes block earlier river-cut valleys with flows of lava or falls of ash. In these and many other ways intermont basins are formed, some of large extent, others too small to show on the maps.

It is important to notice that the major ranges of mountains in the world in most places do not form the divides between river basins. A close examination of the maps will reveal example after example of rivers which rise outside of mountain areas and pass through the mountains in gorges. An outstanding example is the Danube, where it passes through the Iron Gate on the border of Romania and Yugoslavia. The Yangtze and the Columbia are two other examples among the

[1]Generalized from A. Heim, *Geologie der Schweiz* (Leipzig, 1919–1921), Vol. I, Table 23; Vol. II, Table 18.

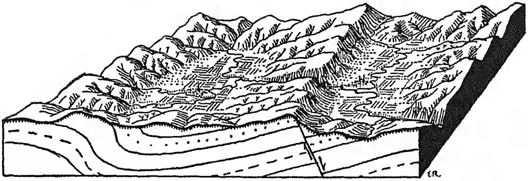


FIG. 169. *Block diagram illustrating characteristic intermont basins*

many which might be mentioned. Such rivers are said to be *antecedent* because they were established in their courses before the mountains rose across them, and as the mountains were slowly lifted up they were able to continue their downward cutting. The Amazon is an example of a river which was unable to maintain its course because the Andes rose so fast; as a result it turned and found a way out to the Atlantic, but its valley is still widest along the eastern front of the Andes and gets narrower downstream.

CLIMATE AND VEGETATION

Climatic distribution in mountain areas is also extremely complicated. Although most of the major types of climate found in other parts of the world occur in mountain regions, the significance of these types in Group VIII is largely obscured by the many important local variations. Nowhere else are "local climates" developed in such large numbers, and nowhere else do they exert such a critical effect on the character of the landscape. Yet this seeming confusion of climatic distribution can be understood through the interplay of two of the principles of mountain geography: the principle of vertical differentiation, based on the effects of change in altitude; and the principle of spotty distribution, based on the effects of different exposures to sunlight and of differences in rainfall.

Vertical Differentiation. The most important climatic element leading to the vertical differentiation of landscapes in mountain areas is temperature. Generally speaking, lower temperatures may be found

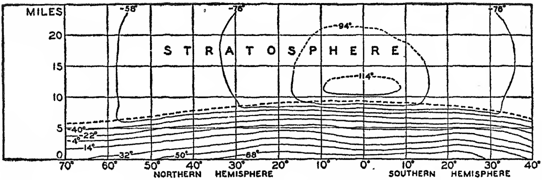


FIG. 170. *Vertical arrangement of the average annual isotherms.* (After Clayton and Ramanathan)

either by traveling along the surface of the earth toward the poles or by ascending vertically above the earth. However, one would have to travel many miles along the surface to find as great a contrast of temperature as is concentrated in only a few miles of vertical distance (Fig. 170). The isotherms which reach sea level in high or middle latitudes rise steeply toward the margins of the low latitudes, gaining their greatest altitude between 20° and 30°, especially over the hot deserts. Although sagging somewhat over the equator, they remain high between the tropics. So it is that mountains on the equator rising to fifteen thousand feet can reach all the average temperatures which are spread over the thousands of miles of horizontal distance between the equatorial and polar regions.

We must not suppose, however, that because a place at a considerable elevation in the low latitudes has the same average temperature as a place at sea level in middle or high latitudes, it also has the same climate. At high altitudes on tropical mountains none of the climates of middle and high latitudes are found. There are none of the cyclonic storms or associated weather changes which are essential characteristics of the middle latitudes. Furthermore, with increase of altitude, there is a decrease of the range of temperature between summer and winter; and in the low latitudes, where ranges of temperature are small even at sea level, this effect is most noticeable. The average monthly temperatures at Quito illustrate this condition (Appendix E). Quito is located nearly on the equator in the Andes of Ecuador at an elevation of 9350 feet. Its average annual temperature is 54.6°, but its range be-

tween the average of the coldest and warmest months is no more than 0.3°. In middle-latitude and high-latitude mountains, on the other hand, the ranges of temperature are not so low as in the tropics, and seasonal change is an important feature.

Snow Lines and Tree Lines. As a result of these vertical distributions of temperature, almost all the landscape features which are affected by temperature not only have horizontal limits bounding their areas of distribution but also vertical limits. One very important altitude limit is the snow line, the boundary of the area covered by permanent snow or ice. Horizontally, the areas of permanent snow and ice are restricted to the polar regions; but the vertical limits are reached by the higher mountain summits even on the equator. As in the case of all altitude limits which are governed in whole or in part by temperature, the snow line corresponds in pattern to the vertical arrangement of the isotherms (Fig. 170). It rises to its greatest elevation near the margins of the low latitudes and declines to its lowest elevation in the high latitudes. Near the equator it is necessary to climb about 15,000 feet to reach the snow line—a little higher than this on Mount Chimborazo near Quito, and a little lower on Mount Ruwenzori in Uganda. Southward

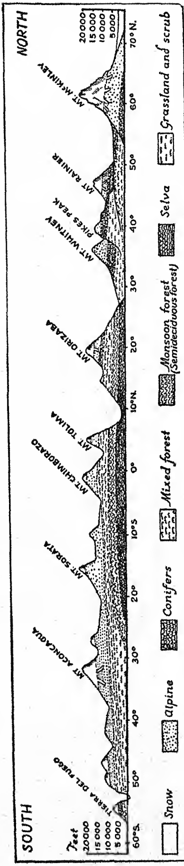


Fig. 171. *Diagrammatic cross section through the mountains of North and South America, showing vertical zones of vegetation.* (Modified from J. Paul Goode.)

Lanks from Caterpillar Tractor Company

FIG. 172. *The Uspallata Pass between Chile and Argentina*

along the Andes the snow line rises to about 16,000 feet near Lima and to more than 20,000 feet at the tropic of Capricorn in northern Chile. South of this, however, it drops rapidly. In Middle Chile it is between 11,000 and 14,000 feet. In Tierra del Fuego it lies a little below 2500 feet. The snow line, however, is obedient not only to temperature but also to snowfall and other things. At any given latitude it lies somewhat lower on the wetter sides of the mountains and somewhat higher

on the drier sides, and it descends farther on shady slopes and remains higher up on sunny slopes.[1]

The altitude limits of the various types of vegetation also correspond to the pattern of vertical temperature distribution. Roughly, the same succession of types is found in ascending mountains near the equator as is found on proceeding poleward along the continental east coasts. The tropical forests occupy the lower slopes; higher up are the mixed forests of broadleaf types; and beyond the upper limit of trees but below the snow line is a zone of alpine meadows not unlike the tundra of the polar margins. Conifers do not appear at higher altitudes south of Nicaragua. Since tree lines are generally higher in rainy mountains and lower in dry mountains, whereas snow lines vary in just the opposite way, it follows that the zone of alpine meadows is widest in dry regions and narrowest where the rainfall is heavy (Fig. 173).

As far as vegetation and other forms of life are concerned, the vertical differentiation reaches a maximum in the low latitudes. Here we find the greatest variety of zones. Vertical differentiation remains a conspicuous feature of mountains in the middle latitudes, but it disappears altogether in the high latitudes. The criteria suggested in the introduction to this chapter for the recognition of "conspicuousness" in mountains can be used, therefore, only in the middle and low latitudes, not in the polar zones (Fig. 171).

Other Climatic Elements. Certain of the other elements of climate act to reinforce the effects of temperature in producing a vertical differentiation. Rainfall, for instance, develops something of a vertical zoning. Up to six thousand or seven thousand feet in the middle latitudes, and somewhat higher in the low latitudes, the rainfall on mountain slopes increases; but above this zone of maximum fall the amounts diminish. At higher altitudes the specific humidity of the air becomes very low. Unbroken ranges of high mountains are very effective barriers to the passage of moisture.

Pressure is another climatic element which decreases with increasing altitude. Its results, however, are of less significance than those of

[1]See W. Heybrock, "The Interval between Tree and Pasture Lines and the Position of Their Extremes," *Geographical Review*, Vol. 24 (1934), pp. 444–452.

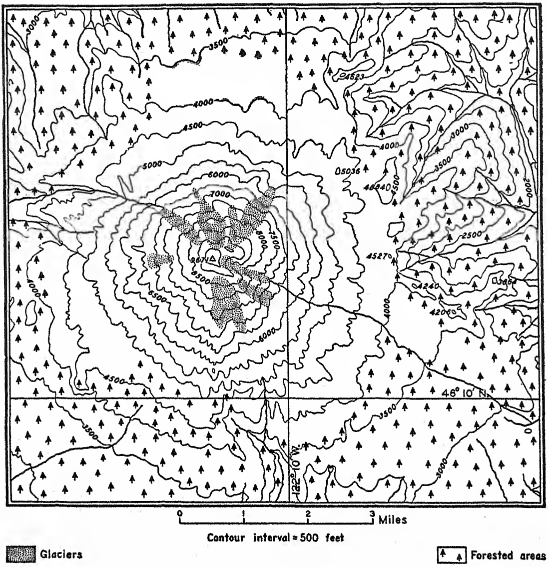
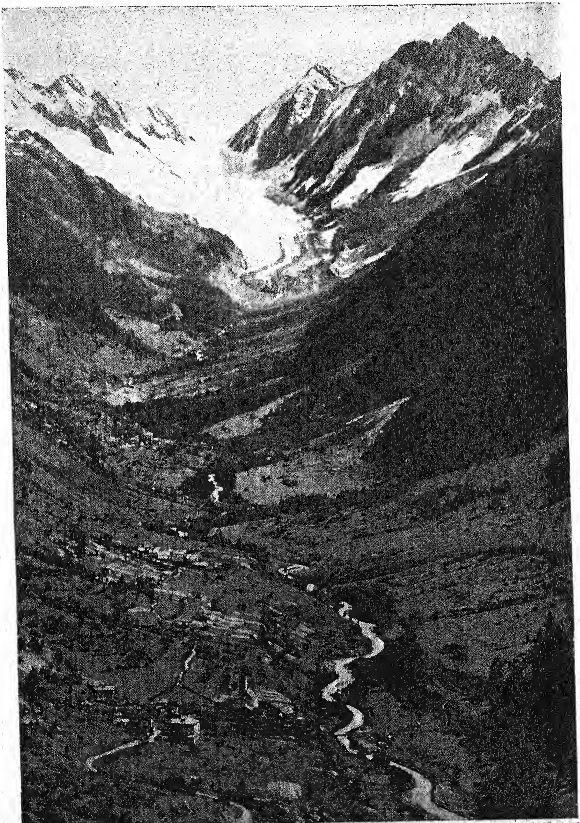


FIG. 173. *Topographic detail on Mt. St. Helens, Washington.* (From Mt. St. Helens Quadrangle, Washington, United States Geological Survey)

temperature and rainfall. At elevations above twelve thousand or fifteen thousand feet many human beings are affected by altitude sickness, and at very high altitudes the difficulty of breathing forms a distinct limit to occupance. Decreased pressure also lowers the boiling point of water so that the cooking of foods by boiling takes much longer, or may become altogether impossible without pressure cookers. When Marco Polo observed this phenomenon in his journey across high Tibet, he explained it as the result of the low temperatures. "Even the fire," he wrote, "is not hot enough to cook foods."



Photograph by J. F. Unstead

Fig. 174. *Looking northeast up the Lötschental in Switzerland*

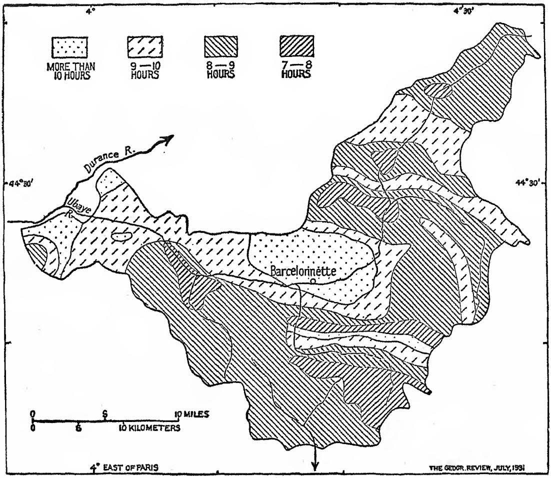


FIG. 175. *Hours of sunlight in the valley of Barcelonnette.* (By A. Levainville; courtesy of the *Geographical Review,* published by the American Geographical Society of New York)

Spotty Distribution Patterns. The vertical differentiation of mountain landscapes, resulting from the variation of these several factors with altitude, is greatly modified by the irregularity of the terrain. Steep slopes oriented at various angles to the sun's rays; narrow valleys with winding courses; mountain-rimmed bits of flattish valley floor or delta plain: all these features combine to add complexity to the otherwise simple arrangement of things in vertical zones.

Local contrast in exposure to sunlight is one of the important causes of spotty landscape patterns. Slopes which face toward the sun not only absorb much more heat than those which receive the sun's rays more obliquely, but they also enjoy many more hours of sunshine. In the Northern Hemisphere the north sides of east and west valleys, such as

the upper Rhône Valley in Switzerland, are much warmer than the south sides at the same altitude, and these temperature differences are reflected in striking landscape contrasts—contrasts in natural vegetation, in occupance, and even in landforms (Fig. 174). So great are these differences that the two sides have been distinguished by the names *adret*, meaning "sunny side," and *ubac*, meaning "shady side."[1]

The adret and the ubac are generally not arranged symmetrically on the two sides of the valley, however; for where towering peaks cast shadows over the neighboring terrain the patterns of light and shade are amazingly intricate. A map of the average daily hours of sunlight in the valley of Barcelonnette, in the French Alps, suggests at least one reason for the characteristic spottiness of mountain landscapes (Fig. 175). The resulting temperature contrasts from place to place may be sufficient in any locality to wipe out quite completely the general decrease of temperature with increase of altitude, and so to obscure the vertical zoning.

Another climatic element which contributes to the intricacy of mountain patterns is rainfall. While it is true that rainfall exhibits a certain vertical arrangement,—increasing, as we have pointed out, up to a zone of maximum, and decreasing beyond that,—still in most mountain areas this feature is only vaguely developed. Vertical zoning of rainfall is most apparent on mountain sides which present a relatively unbroken wall to the air currents, as the eastern slopes of the Andes, the southern slopes of the Himalayas, and the western slopes of the Sierra Nevada of California. In most mountain areas the great contrasts in the amount of rain received, even on neighboring slopes which are oriented somewhat differently to the rain-bearing winds, make it difficult or impossible to observe any general increase or decrease with altitude (Fig. 176). As we have seen, the world's heaviest rainfalls occur on the windward slopes of mountains up which warm, moist air

[1] "The matter of sunlight is so dominant that each dialect of European mountain peoples has a set of terms for sunny side and shady side. Thus the German, *Sonnenseite, Schattenseite*; *Sonnenberg, Schattenberg*; French, *adret* (Latin, *ad directum*), *ubac* (Latin, *ad opacum*); *endroit, envers*; Italian, *indritto, inverso*; *adritto, opaco*; Catalan, *sola, baga*; *solana, ubach*; *soula, umbaga*. One may so name a village or a shady portion of a village, as Envers de Fontenille or Inverso Pinusca." Quoted from R. Peattie, "Height Limits of Mountain Economies," *Geographical Review*, Vol. 21 (1931), pp. 415–428.

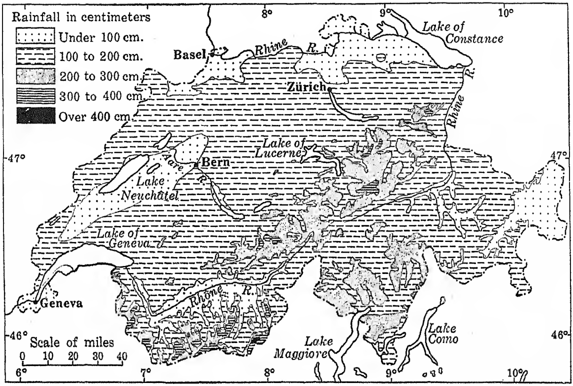


FIG. 176. *Rainfall of Switzerland.* (After J. Maurer and J. Lugeon, 1928)

is rising buoyantly (Kauai and Cherrapunji). Where the mountains are high, the windward slopes are generally much wetter than the lee slopes, which lie in a *rain shadow*; but where the mountains are lower, the clouds which form over them may drift to leeward and bring more rain to that side. Basins and deep valleys into which the wind must descend are usually dry; but, on the other hand, where the wind blows up through a valley, it may bring copious rainfall. The actual rainfall distribution in a rugged mountain region composed of slopes standing at various angles to the winds forms a pattern which is even more intricate than that of the hours of sunlight. Furthermore, these two patterns in no way correspond; so that the landscape features, which are in part conditioned by sunlight and in part by rainfall, find in mountain regions the most extraordinary number and diversity of combinations of these elements. If to these things is added the variety of edaphic conditions, we can appreciate the basic reasons for the spottiness of mountain landscapes.

The Occupance

Mountains resemble the deserts in the persistent effect they exert on the distribution of the human occupance. In most parts of the world the character of the occupance patterns is largely determined by the culture which produces them, and a succession of cultures in any one area may result in a series of occupance patterns which are radically different one from another. In the mountain lands, on the contrary, the location of settlements and the routes of travel established by different cultures are as closely fixed by the rugged terrain as they are in the dry lands by water. Only in topographic detail can they vary. The general characteristics of mountain distribution patterns may be illustrated not only from the physical elements but also from elements of the occupance. Vertical differentiation appears in many forms; spotty arrangement reflects the diversity of habitat background; and the barrier nature of mountains leads to the convergence of routes on the passes and to the historical persistence of these routes.

VERTICAL DIFFERENTIATION

The vertical differentiation of occupance is developed in almost all the mountain regions which have gone beyond the pioneer stage. Even early in the progress of settlement, when the main routes of travel are of chief importance in guiding the arrangement of population, a vague altitude zoning is usually apparent; but as settlement is elaborated, vertical zones, differing from one another in the modes and forms of occupance, become more and more sharply differentiated. While this stratification is an almost universal feature of mountain regions, the actual modes of occupance at the various levels differ from place to place. In the low latitudes, for instance, the occupance has a tendency to become static, with little movement from one altitude to another; but in the middle latitudes in most mountain regions a regular seasonal migration up and down the slopes is developed. Throughout the world the differing cultures of the mountain dwellers find expression in the many and various methods in which the resources of the several altitude zones are utilized. In other words, while some form of

vertical arrangement appears in the occupance of almost every mountain region, the ways in which this arrangement is worked out are in large measure unique for each group of people.

Altitude Limits. The altitude limits of the various forms of human settlement are in many respects similar to the horizontal limits of these same forms in the other landscape groups. In most cases such limits are a reflection more of the culture of the people than of rigidly imposed natural barriers. However, in general, the same crops reach the upper limits of agriculture as reach its poleward limits, and there is a similar sequence of crops down the slopes or equatorward.

The extreme upper limits of settlement differ in the various mountain regions not only with such natural features as the snow line and tree line but also with the historical and cultural background of the inhabitants. The highest human habitation is reported by Bowman in the Andes of southern Peru, at an elevation of 17,100 feet,[1] only a little below the snow line. Settlement at this great elevation, however, is the result of certain peculiarities of the occupance in this region. Neither of the major culture groups in the Peruvian Andes, namely, the Indians and the Europeans, would, if left to itself, have established a permanent settlement at such an altitude. But the European has appropriated the better lands at altitudes suitable for his commercial crops, and the poor Indian has been forced to seek refuge at still higher altitudes where a scanty pasturage for his sheep and llamas may be had. In each mountain region the upper limits of settlement represent a compromise between the traditional mode of occupance, the historical background of the people, and the peculiarities of the local terrain. We may say in general, however, that the highest settlements are usually associated with mining; in fact, some mining communities have been established above the snow line. The next highest settlements are commonly supported by the pasturage of domestic animals. Lower down, the various types of agricultural settlement appear.

Both the animals and the crops which support these settlements show fairly distinct upper limits in any one region. Because sheep can

[1]See the chapter on the Andes by I. Bowman, in J. Brunhes, *Human Geography* (Chicago, 1920), pp. 453–498; reference on page 468.

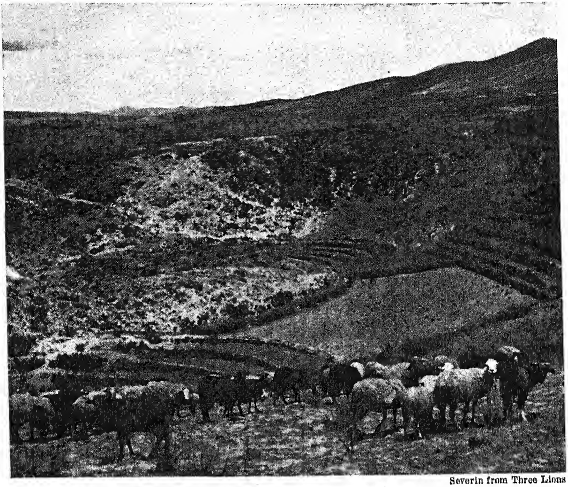


Fig. 177. *Sheep in the Peruvian Andes*

exist on much scantier pasturage than cattle, they are the domestic animals which are driven highest in the mountains. Cattle and horses usually occupy the richer pastures lower down. Of the crops, the potato reaches the highest altitudes, just as it reaches the highest latitudes. Lower down, the various grains arrange themselves in the expectable sequence: barley, rye, wheat, maize, and rice in descending order. The tropical crops occupy the lower slopes of low-latitude mountains.

Vertical Zones. Most mountain people recognize in the region they inhabit fairly definite zones of altitude, to which they give distinguishing names. For the reasons previously suggested, the number of these zones is greatest in the low latitudes. In any region, however, these popularly recognized zones, when analyzed, prove to represent a generalization of a considerable number of altitude limits: crop limits,

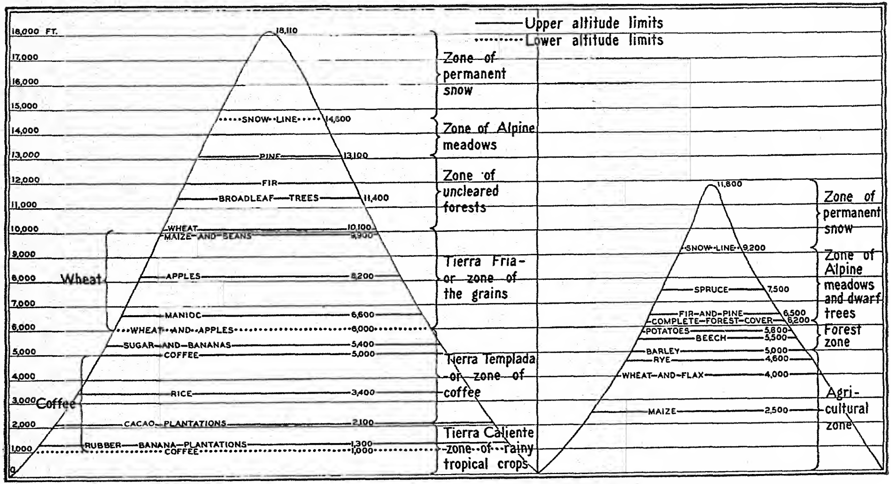


FIG. 178. *Altitude limits and vertical zones on Mt. Orizaba, Mexico (19° N.).* (After Sapper)

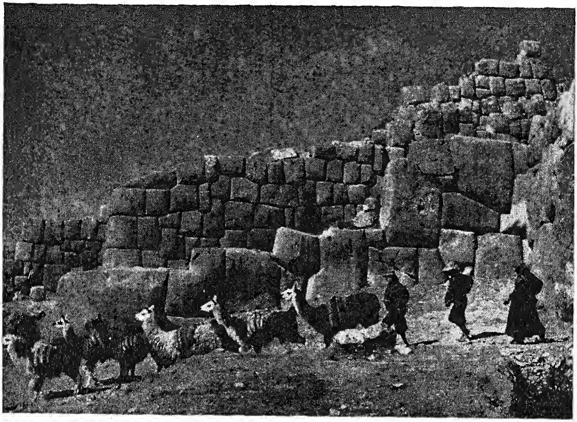
Altitude limits in the Ötztaler Alps, Austria (47° N.). (After Sapper)

limits of various types of settlement, even limits of racial groups. A few specific examples will illustrate this more clearly.

On the slopes of Mount Orizaba in Mexico, at about latitude 19° N., six vertical zones are given popular recognition (Fig. 178).[1] The two upper zones are simple concepts, each based on one dominant feature. At the top is the zone of permanent snow, lying above 14,600 feet (to the peak at 18,110). The zone of alpine meadow lies between 13,100 feet and the snow line. The forest zone is not so simple as the upper two, for it is differentiated by the altitude limits of the various trees into three parts: a lower part of mixed broadleaf trees and conifers, a middle part of pine and fir, and an upper part where pine alone can exist. The upper limit of agriculture as practiced on Orizaba lies about 10,100 feet above sea level. This corresponds to the upper limit of wheat. At various altitudes below 10,100 feet are found in succession the upper limits (in some cases the lower limits) of the various crops. As a result of certain typical combinations of crops, however, the agricultural occupance is divided into three zones. The *tierra fria* (roughly from 6000 to 10,100 feet) is essentially the zone of wheat cultivation. Manioc, apples, maize, and beans are associated with wheat at the bottom of this zone, but all these other crops disappear, one after another, as one ascends. Below the *tierra fria* is the *tierra templada* (from 2100 to 6000 feet). This is primarily the zone of coffee culture, although coffee does not quite reach the top, nor does its cultivation stop at the bottom. Associated with coffee up to their respective altitude limits are sugar, bananas, and rice, as well as maize, manioc, and beans. The lowest zone is the *tierra caliente*. This is the zone of rainy tropical crops: cacao, bananas, rubber, sugar, rice, maize, manioc, and beans.

The vertical zones recognized in the Ötztaler Alps in Austria, at the head of the Adige Valley, are similarly composed of various individual limits (Fig. 178). The zone of permanent snow is above 9200. Below this lies the zone of alpine meadow and dwarf trees, within which, however, pine, fir, and spruce have their successive upper limits. The

[1]Karl Sapper, *Allgemeine Wirtschafts- und Verkehrsgeographie* (Berlin, 1930), pp. 66–67. The altitudes on Fig. 178 and in the corresponding parts of the text are translated from the metric system to the nearest round numbers of feet.



Three Lions

FIG. 179. *A pack train of llamas in the Peruvian Andes*

zone of continuous forest cover begins about 6200, while the upper limit of the agricultural zone is about 5000 feet. Within the forest zone are found the upper limit of broadleaf trees (beech) and the upper limit of crops (potatoes). Only one agricultural zone is recognized, although it is diversified by the limits of barley, rye, flax, wheat, and maize. There is no *tierra templada* or *tierra caliente.*

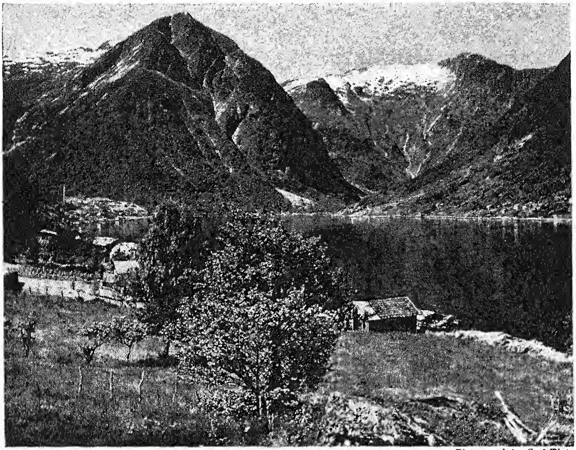
In many of these mountain regions there is a stratification of people as well as of crops. We have already pointed out that in the Peruvian Andes the Indians, with their domestic animals and their subsistence crops of potatoes, barley, wheat, and maize, are now concentrated at the higher altitudes, while the Europeans, with their commercial crops of cotton and sugar, occupy the lower slopes and the coastal desert. Similarly, in Colombia the Indians are most numerous at the higher altitudes, where they have been forced by the white man's appropriation of the better lands lower down. The Spanish Americans for various reasons avoided the hot, humid, unhealthful lowlands in South America

and Middle America, concentrating their settlements in the zones of grain cultivation and of coffee cultivation. Meanwhile the *tierra caliente* has been occupied chiefly by Negroes, the descendants of former slaves who, upon being freed, sought what was to them a more congenial climate at the lower altitudes. As in the case of the low-latitude plateaus, discussed in Group II, the occupance of the mountain basins above 2000 or 3000 feet provides freedom from the ravages of malaria and yellow fever, but at the same time it raises seriously the problem of mountain transportation. Most of these Spanish American settlements suffer from difficult accessibility to markets—an item of the greatest importance to Occidental peoples, for whom a commercial connection with the economic world is one of the necessities of successful colonization.

Contrasts between the Low and Middle Latitudes. In the low-latitude regions regular seasonal movements up and down the mountain slopes are of relatively minor significance. Not that such movements do not take place; in many regions inhabited by Europeans or Americans the ruling classes abandon their lowland towns during the hot season and ascend to highland settlements (New Delhi to Simla, Manila to Baguio, Rio de Janeiro to Petropolis); in other places there is a shift of the agricultural occupance up and down the slopes in harmony with the rains (as on the eastern slopes of the Andes).[1] Such movements, however, are of small importance. On the whole, the stratification of people and crops in the low-latitude mountains is static. In fact, the vertical contrasts in occupance become well enough established so that locally important currents of trade are developed between the lowland dwellers and the highland dwellers, based on the vertical differentiation of products.

There are two reasons why the occupance in most middle-latitude mountains does not achieve this permanence of stratification. In the first place, there are fewer vertical zones and so less opportunity for the development of different layers of contrasted types of occupance. There are no zones of tropical products or of coffee below the zone of grain-farming; and as one proceeds poleward, even the zone of grain-farming

[1] I. Bowman, *The Andes of Southern Peru,* New York, 1916.



Photograph by Carl Tietz

FIG. 180. *A branch of the Sogne Fiord, Norway, latitude 61° north, in summer*

is forced to lower and lower altitudes until it disappears altogether, and the forest zone descends to sea level. In the second place, the marked seasonal change, which is lacking in the low latitudes, renders the higher mountain slopes productive only at certain seasons. There is a tendency, therefore, for the mountain peoples to establish their homes at the lower altitudes and to ascend each summer with their domestic animals to take advantage of the excellent pasture lands of the alpine meadows.

Transhumance and Seasonal Seminomadism. The movements up and down the slopes of middle-latitude mountain ranges in response to the rhythm of the seasons are of two chief kinds. There are movements involving only the herds or flocks of domestic animals accompanied by a small number of attendants, and there are movements involving not only the animals but also the whole human group. These

Photograph by Carl Tietz

FIG. 181. *The same scene as in Fig. 180 in the winter. The fiord is not frozen over*

kinds of movement are called, respectively, *transhumance*[1] and *seasonal seminomadism.* Transhumance is a widespread phenomenon. It is reported from nearly all the lower middle-latitude mountain regions of the world, with one striking exception to be described later. The flocks of sheep of the pastoral nomads of inner Asia are driven into the mountains during the summer, and a similar combination of transhumance and nomadism is practiced in the southern Andes of Ar-

[1] "Transhumance" is a word borrowed from the French. It is derived from a combination of *trans*, meaning "across" or "over," and *humus*, meaning "the ground." As a term, "transhumance" denotes the periodic, or seasonal, movement of flocks or herds of domestic animals between two areas of different climatic conditions. Such climatic differences within relatively short distances are found in mountains, and the term "transhumance" is therefore associated with the seasonal movements of domestic animals in mountain areas. A distinction is made between the Greater Transhumance, involving movements between a mountain region and its surrounding lowlands or plateaus, and the Lesser Transhumance, which includes movements within the mountain region from lower to higher slopes. E. H. Carrier, *Water and Grass, a Study in the Pastoral Economy of Southern Europe*, London, 1932.

Black Star

Fig. 182. *Cattle in the Swiss Alps*

gentina and Chile. In the North American mountains transhumance without any form of nomadism is the rule; sheep are driven to the higher pastures above the timber line, and cattle and horses to the pastures at lower elevations, many of them in the open forests of these regions. Similar movements of animals are reported from Australia and New Zealand.

Transhumance combined with seasonal seminomadism was formerly an outstanding feature of mountain occupance in Europe, especially southern Europe, where the nomadic tradition was a culture trait of the mountain peoples. These movements of the people as well as of the animals continue even today, but in a form much modified by modern transportation. In some of the mountain valleys of the Alps an exceedingly complex series of migrations up and down the slopes takes place. After passing the winter in stables in the valleys, the animals are started up the mountains early in the spring. They are driven first to the lower pastures (known as the *voralps*), and then, as the snow melts, they proceed by stages to the pastures above the tree line (known as the *alps*). Meanwhile the human group carries on various

activities at different levels—now climbing to harvest a crop of hay from the alpine meadows, now descending to care for grains or vegetables planted in the valleys, now ascending again to make cheese at the settlements on the alps.

The most complex of such movements was described by Brunhes in the Val d'Anniviers, a tributary of the Rhône in Switzerland.[1] In this valley the inhabitants have several permanent villages at different altitudes, and some of the people can be found at almost all times of the year ascending or descending the mountain roads between their different habitations. Their activities extend from vineyard cultivation in the Rhône Valley to cheese-making in the alpine meadows near the snow line. This very active and self-sufficient community, however, is now being changed considerably by the establishment of tourist hotels in the upper part of its valley. The economic life will suffer a profound modification as a result of this closer contact with the outside world.

The Lack of Transhumance in Japan. Japan is a notable exception to this general rule of mid-latitude mountain occupance. Until recently there was little or no pastoral utilization of the mountain slopes to supplement the intensive agricultural use of the valleys and coastal lowlands. The Japanese culture contains no traditional familiarity with domestic animals, for other than draft purposes, to suggest the use of the mountain pastures; nor are the pastures of much value in the high mountain area of Japan, owing to the growth of nonedible bamboo grass and sedge. A distinct vertical zoning is developed which remains undisturbed by important vertical movements, in spite of the rhythm of the seasons. Agriculture, based primarily on rice, is concentrated in the valleys, the intermont basins, and the coastal lowlands (Fig. 184 and 185). Certain dry-land crops, such as tea or mulberry, are planted on the lower slopes. Above this zone of cultivation the Japanese mountains are forest-clad, and into this zone come a few charcoal-makers during the summer months. Still higher are the unoccupied alpine meadows, just below the snow line.

[1]See Chapter VIII in J. Brunhes, *La Géographie humaine*, Paris, 1925; and also P. Arbos, "The Geography of Pastoral Life," *Geographical Review*, Vol. 13 (1923), pp. 559–575.

SPOTTY DISTRIBUTION

The mountain lands resemble the dry lands in the prevailing scantiness of population. Yet, as in the dry lands, there are in these regions numerous small areas of very dense population,—some of the densest in the world. The concentration of the occupance in the valleys, basins, delta plains, or other bits of flattish land at appropriate altitudes is an outstanding feature. The resulting patterns of occupance are no less spotty than the background of the physical setting. The areas of concentrated settlement are of various sizes and shapes, but each community is more or less isolated from other communities by uninhabited slopes over which communication is very difficult.

Relation of Settlements to Landforms. Among the mid-latitude mountain regions there are many illustrations of the concentration of people and their settlements in the small areas of favorable land. The densely populated lowlands, with their big cities, form a striking contrast to the scantily populated highlands in such small countries as Switzerland and Austria. The canton of Zürich in Switzerland, a lowland canton, has more than seven hundred people per square mile, whereas the canton of Valais, in the highlands, has only about sixty per square mile, and these are mostly in the valley of the upper Rhône (Fig. 190).

A map of the land utilization in Andorra brings out these relationships quite clearly (Fig. 183). Agriculture in this mountain state in the Pyrenees is limited to a few cultivated crops and to hay cut from untilled meadows. The agricultural lands follow the valley of the Río Balira and its tributaries. The sequence of widened intermont basin and narrow, steep-walled gorge, which is characteristic of mountain streams descending over rocks of varying degrees of resistance, is revealed in the pattern of the agricultural land. The concentration of the small villages in these basins can be seen, and also the location of the chief town, Andorra, in the midst of the largest basin. Only a small proportion of this little country is devoted to agriculture; much more of the area is alpine pasture with a few patches of forest. But the various parts of the territory are divided into small units by slopes too steep

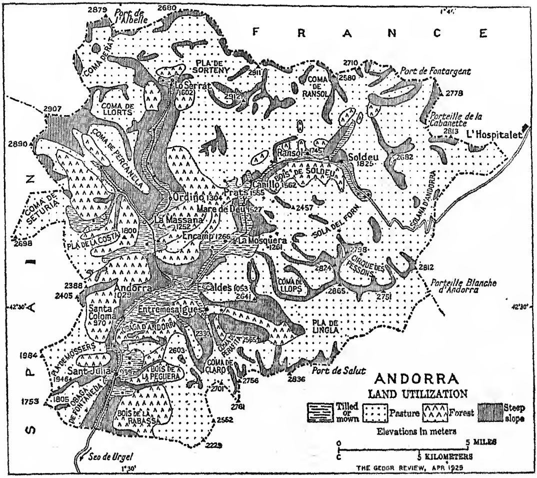


Fig. 183. *Land and settlement in Andorra.* (By R. Peattie; courtesy of the *Geographical Review*, published by the American Geographical Society of New York)

for any kind of use,—slopes which follow either the sides of the main valleys or the mountain crests.

The relation of population distribution to areas of relatively level land is also illustrated by two maps of the central mountainous part of the Japanese island of Honshu (Figs. 184 and 185). The number of people in any given territory is in rather strict proportion to the size of the plains and basins, much as in the dry lands, where the population of an oasis is strictly proportional to the available supply of water. Tokyo and Yokohama occupy the Kwanto Plain, the largest in Japan. Other large cities, such as Nagoya and Osaka, occupy other plains of considerable extent. Many small villages and towns are strung along the coast on the smaller delta plains and coastal terraces, while back in the mountains each intermont basin and narrow valley bottom stands

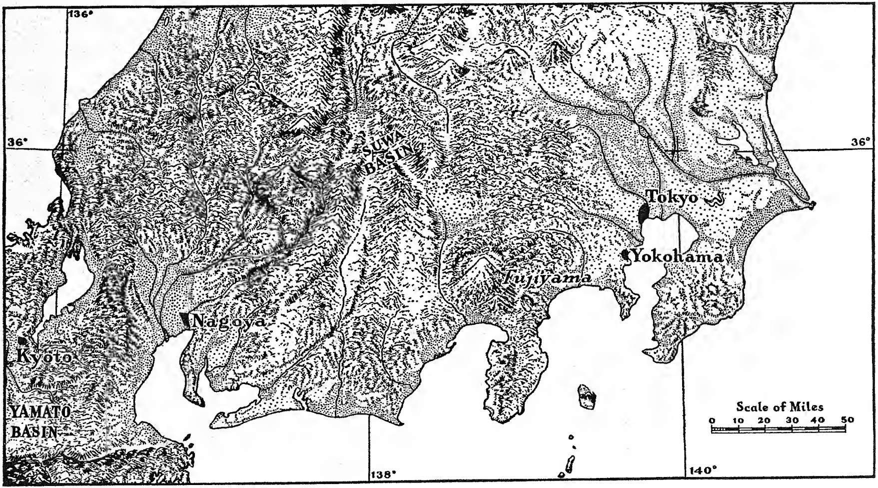


Fig. 184. *Surface features of central Honshu, Japan.* (Map by Guy-Harold Smith from *Notes on a Physiographic Diagram of Japan*, by Glenn T. Trewartha. Courtesy of the *Geographical Review*, published by the American Geographical Society of New York)

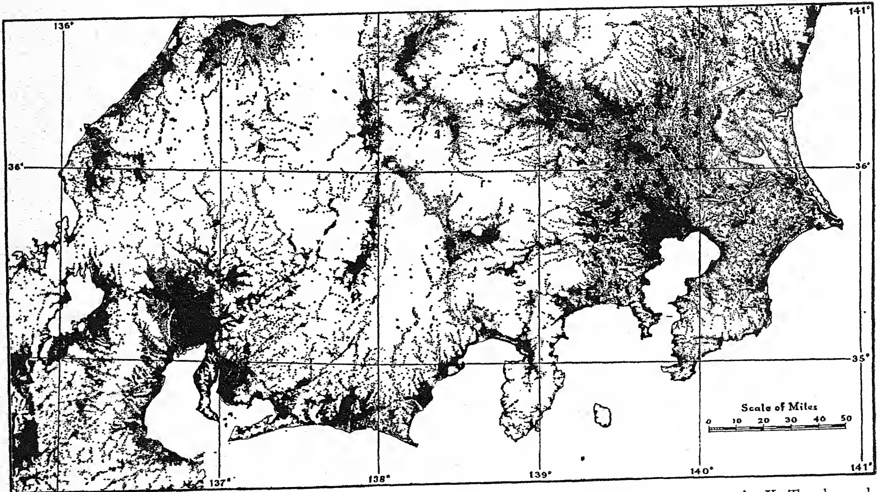
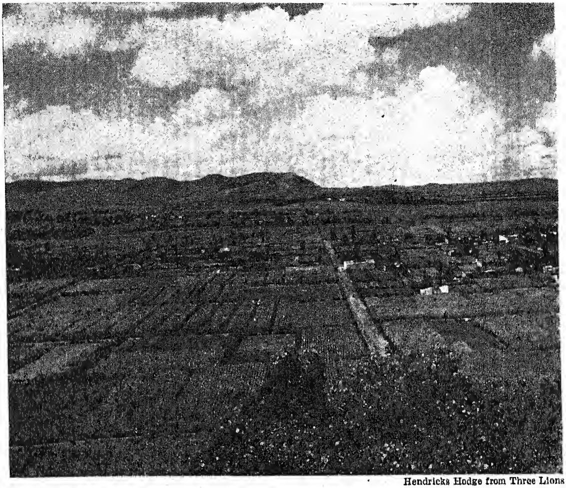


Fig. 185. *Population of central Honshu, Japan.* (Each dot represents two hundred people. From map by K. Tanaka and K. Yamamoto, based on 1925 data)

out clearly on the population map. Yet the greater part of the territory is only scantily inhabited, so rugged are the slopes.

Although this tendency to concentrate on the lowlands is repeated by various cultures in the mountain lands, there are a few regions where the lowlands have been avoided in favor of the higher intermont basins. This is notably the case in most parts of Spanish America. So common is the concentration of settlement in the highlands, leaving the low coastal regions almost uninhabited, that many writers have insisted that this was a result of the avoidance of the hot lowland climates. The historical fact is that the Spaniards came to the New World seeking gold or other sources of quick wealth, and also large numbers of sedentary Indians who could be converted to Christianity and set to work in the mines or fields. Such groups of Indians at the time of the Spanish conquest were to be found in the intermont basins of Mexico, Guatemala, Colombia, Ecuador, Peru, and Bolivia. To these places the Spaniards directed the main streams of settlement. But where the largest number of Indians were found in the lowlands, the Spanish settlements were also established in the lowlands, as in the Dominican Republic and in Nicaragua. The Mexicans in the high Basin of Mexico found the continuously cold climate so tiresome that they established a resort city, Cuernavaca, in the tierra templada close by. In other words, the kinds of places sought for the establishment of settlements in mountain regions depends on the cultural traditions of the people; but in any case, the chief areas of concentrated settlement are to be found on the relatively gentle slopes (Fig. 186). Settlements on very steep slopes are usually associated with mining, or are found to be places of refuge, such as Machu Picchu in Peru.

Relation of the Settlements to Local Climates. Few generalizations can be made concerning the relation of settlements to the various local climates of these mountain lands. In dry mountains, for instance, the rainy places are preferred; but in rainy mountains the inhabitants commonly seek the sunny, dry, lee sides, as in the Hawaiian Islands. In the mid-latitude regions the sunny slopes are usually so much more desirable than the shady slopes that a definite separation of the wealthier people from the poorer people takes place, the former occupying the



Hendricks Hodge from Three Lions

Fig. 186. *Farm land in an intermont basin in highland Mexico*

adret, the latter the ubac. In the low latitudes, on the other hand, the shady side is chosen first, and the poorer settlements occupy the sunny slopes. The greatest variety of local adjustments is possible. Thus there may arise not only a vertical stratification of people, as in the Andes, but also a complex rearrangement within the same vertical zone to conform to the different details of slope and local climate.

MOUNTAINS AS BARRIERS

Because of the steep slopes, the narrow valleys, and the rigorous climates of high altitudes, especially in the middle latitudes, mountains have played the role of barriers to the movement of people on the earth. The mountains tend to isolate and separate the communities within the mountain regions, and also the peoples on either side.

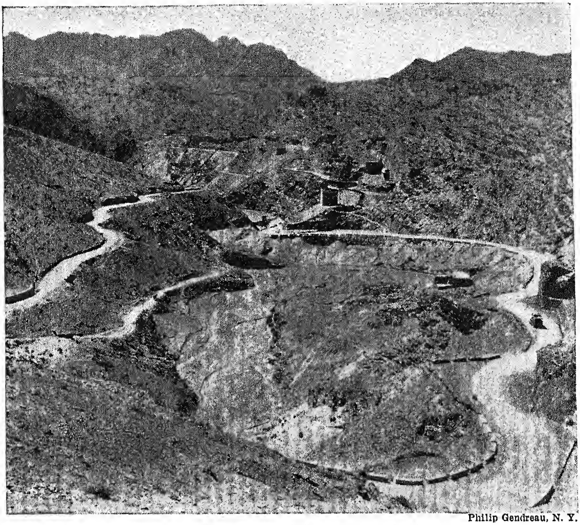


FIG. 187. *A zigzag route through the Hindu Kush Mountains*

The Isolation of Mountain Communities. The isolation of mountain communities is difficult to overcome. Steep slopes require the construction of zigzag trails which cling precariously to the ledges of the valley side. Avalanches, especially on the rain-soaked valley sides of tropical mountains, frequently obliterate parts of the trails and render communication uncertain. If the trails reach considerable altitude, the obstacles of snow, high winds, and low temperatures are added to the difficulties of rugged surface. Yet, in spite of these difficulties, it is quite commonly easier to gain access to an intermont basin by climbing over its mountain rim than by attempting to follow the narrow, steep-walled gorges along the river. It is in such places that anthropologists look for survivals of older races and cultures, which, without the protection afforded by the isolation, would have been submerged.

The resources of mountain lands, moreover, are in many regions insufficient to pay the huge cost of railroad and highway construction. Those mountain basins which happen to lie close to a pass route may find the problem solved with relative ease, but the more remote Occidental communities must pay their own way if they are to be connected with the urban centers. Probably the chief support for railroad development away from the pass routes has come from mining and lumbering. Industrial development—especially of such industries as the manufacture of paper or matches, which can make use of both timber supplies and water power—has resulted in railroad construction. More recently tourist establishments have supported the building of railroads and highways.

Pass Routes. Mountain ranges, also, play the role of barriers between the territories on either side. In this capacity mountains have shaped the course of history at many critical times. The importance of the Alps and Carpathians in shielding the growing cultures of the Mediterranean lands, or of the Himalayas in shielding India, can scarcely be overemphasized, although both these barriers were crossed at one time or another by conquering peoples. Because mountains are barriers the interests of the inhabitants of a wide extent of territory are focused on the pass routes. These become nodal points of great strategic importance, not only from the military point of view but also from the commercial and political points of view.

Pass routes across mountain ranges are developed not only as a result of the existence of an easy natural line of travel, but also in response to a demand for communications. Many easy natural passes are followed by little-used trails, as in the southern Andes, because the arrangement and needs of the people on either side bring about no insistent demand for a line of travel. On the other hand, many of the actual roads or railroads which cross mountain barriers in places where the demand for communications from a large territory is concentrated follow very difficult routes. Fortunate, indeed, are those few places where world routes of travel come to a focus on a relatively easy pass, such as the Isthmus of Panama. In any case, few pass routes bear any relation whatsoever to the local resources of the mountain area;

they are developed in response to conditions elsewhere in the world. The greatest contrasts may therefore be found between the settlements along the routes themselves and the settlements of the mountain dwellers only a short distance away.

Considering the arrangement of the mountains in the world as a whole, we can place pass routes in two categories. There are the passes which cross the mountainous rim of the Pacific Ocean, and there are the passes which cross the great east-west mountain barrier of southern Asia and Europe. But the rim of mountains around the Pacific is broken in the north and south and especially in the southwest. There is no barrier problem involved in sailing from the Indian Ocean into the Pacific. In Asia also the chief difficulties standing in the way of overland communication between China and the Western world are not those of mountains but, rather, those of aridity combined with low winter temperatures. The mountain rim of the Pacific is most effective as a barrier in the great north-south extent of the American ranges. To illustrate the development and historical importance of pass routes over these great barriers, let us consider a few examples.

The Panama Route. The importance of the Panama route is especially great because, at least up to the present, this route has no competitors close by. Not only the great width of a large part of the continents of North and South America, but also the height of the passes over the western mountains, has helped to emphasize the focus of lines of travel on this point in the barrier. In the country of Panama the mountain backbone of Middle America drops to such a low elevation, while still retaining the characteristics of steep slopes and narrow valleys, that a passage from one side to the other may be had by a climb of only two hundred and eighty-five feet through the Culebra Pass. The surface here has been deeply eroded under rainy tropical conditions, resulting in steep slopes, deep clay soils, and the danger of frequent landslides. The whole region was originally covered with a selva.

Inevitably the Isthmus became the focus of transportation routes. A road from Portobelo, on the Caribbean (northwestern) side, crossed the mountains by the Culebra Pass and descended to the Spanish

colonial town of Panama, on the Pacific (southeastern) side. Panama was the base from which proceeded the conquest of western South America; and later the entire trade between Spain and its South American colonies was limited by law to the route by way of Panama. Boats from Spain brought goods to Portobelo; thence the goods were carried by mules over the Isthmus to Panama and there were reshipped south. The road across the pass, used chiefly by mules, served until about 1850, at which time the stream of American gold-seekers, on their way from the eastern part of the United States to California, stimulated the construction of a railroad.

In 1876 the French, encouraged by their success in Suez, sent a mission to Panama to survey a route for a canal. In 1881 a French company started work near Colon, attempting to dig a waterway like the Suez, without locks. Two things blocked success. The construction of a canal at sea level was much more difficult in Panama than at Suez, for in the latter case there was no mountain range to cross, but only a low ridge; and the rainy tropical climate of Panama, with its disease-carrying mosquitoes, was very different from the desert climate of Suez, where there is little penalty for poor sanitation. But the canal project was too important, considering the geographical position of the Isthmus, to permit its abandonment. In 1904 a project under the control of the United States was undertaken, beginning with an expensive and widespread program of sanitation. The draining of swamps and the clearing of luxuriant vegetation cost too much for the average tropical community; but if yellow fever, malaria, and other diseases now common only in the tropics are to be eliminated, it must be by the elimination of breeding places for the mosquito. The new canal project included the construction of a huge dam at Gatun and the flooding of the valley of the Río Chagres. Access to the lake, which is some 40 feet above sea level, is gained through locks. The Gaillard Cut carries the canal across the divide to the Pacific side, and here two sets of locks are used to permit descent to sea level (Figs. 188 and 189). The work was completed in 1914, the first boat passing through the Canal on August 3 of that year.

In return for its independence and the defense of its territory, Panama, formerly a part of Colombia, has leased to the United States

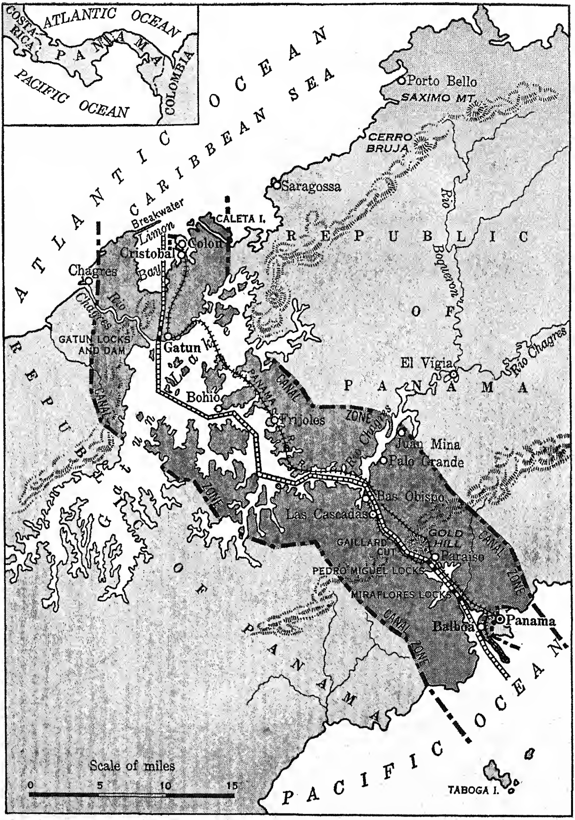


Fig. 188. *The Canal Zone*

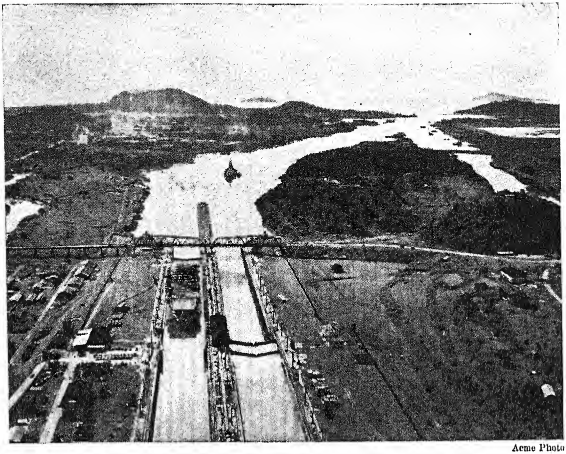

Acme Photo

FIG. 189. *Airview of the Miraflores locks in the Panama Canal*

a strip of land ten miles wide known as the Canal Zone. Within this zone the usual tropical landscapes, many of them still primitive, have been transformed by the magic touch of money and commercial interest. Instead of being left in the wild confusion of a tropical forest or being closely packed with the squalid wooden houses of an isolated tropical city, the country has been cultivated like a park, and the cities of Cristobal (on the Atlantic side) and Balboa (on the Pacific side) are built with wide, paved streets, shaded by trees and bordered by widely spaced white bungalows, and are kept scrupulously clean. The contrasts are extraordinary between the landscapes, both rural and urban, which result from centuries of occupance in Panama, and the landscapes in the Canal Zone, which reflect unlimited financial backing at a focal point in world trade. From the results attained in the Canal Zone, however, it is not possible to conclude that all tropical lands can be similarly developed.

The Brenner Pass. The Brenner Pass, across the Alps, is not so significant to the world as a whole as the Panama route; nor is it so important a crossing of the European mountains as either the Bosporus and Dardanelles straits in the east or the Rhône-Saône Valley in the west (Fig. 68). The Brenner Pass, however, has played a very important historical role. From Verona in Italy to Munich in Germany the crossing of the Alps by this route requires an ascent of 4470 feet (Fig. 190). From the Plain of the Po the Adige Valley, a broad glacial trough, provides an easy route of approach to the divide. From the crest the descent by way of the Inn Valley is only 2767 feet. In this way the Alps may be crossed by a single climb, although elsewhere more than one range must be crossed through higher passes with steeper approaches. As a result the Brenner Pass has been of importance from an early period in history. By this route the Cimbri invaded the Po Valley; and later the Roman forces, marching out to the frontier posts on the Danube, followed it, building a road so that supplies could be sent out to them. Over this pass came the amber from Germany on its way to Rome in exchange for fabrics and wines. The German emperors of the Middle Ages invaded Italy over the Brenner Pass, and later the road through the pass was traveled by people from the north attracted by the culture of Venice. The trade which was carried on over this pass from Venice resulted in the early flourishing of such cities to the north as Augsburg, Ratisbon, Nürnberg, and Leipzig. The first carriage road over the Alps, and later the first railroad, followed the Brenner route. To this day the Brenner is one of the chief lines of travel between central Europe and Italy. Within the mountain area there are only glistening steel rails traveled by heavily loaded trains, and highways over which motor cars or wagons pass back and forth; yet the effect of the pass is felt in the lowlands on either side through the growth of the pass cities—Verona to the south and Munich to the north.

The Khyber Pass. Many mountain ranges cannot be crossed by a single pass like the Brenner. Instead, several ranges must be crossed by means of long, tedious ascents and equally difficult descents. Thus the caravans from the oases of Tashkent and Bokhara seek the markets

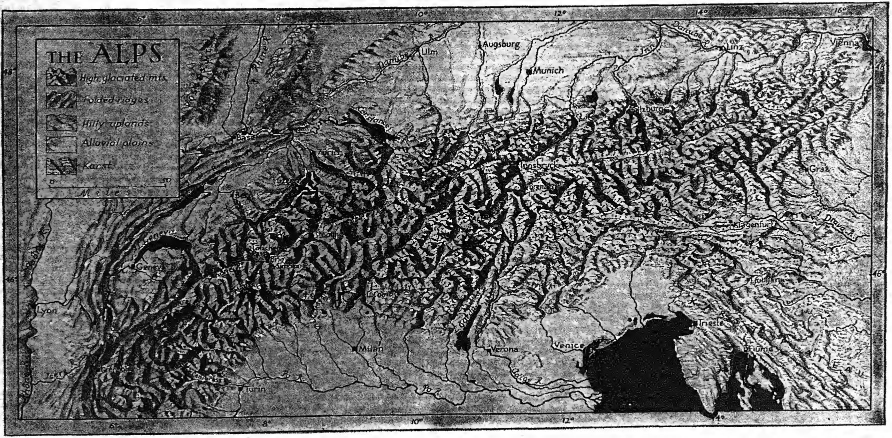


Fig. 190. *The surface configuration of the Alps and neighboring territory*

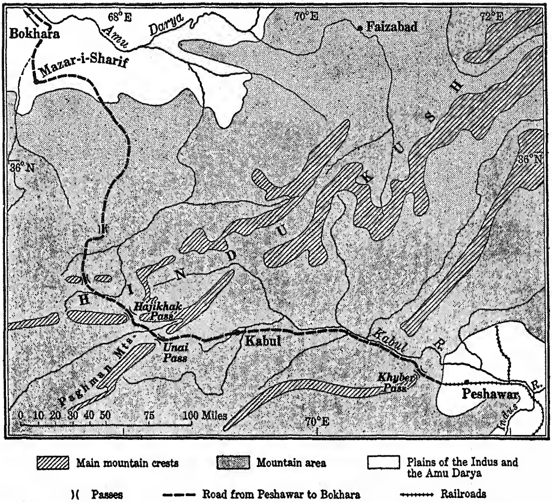


FIG. 191. *The pass route between the Indus Valley and the oases of inner Asia on the margins of the Turkestan*

of India over the ranges of the Hindu Kush by a series of difficult passes (Fig. 191). From the Amu Darya and the piedmont oasis of Mazar-i-Sharif, they cross several lesser divides, finally surmounting the main range of the Hindu Kush Mountains over the Hajikhak Pass at 12,188 feet. Thence they cross the Paghman Mountains by the Unai Pass to Kabul at 5740 feet, and then, after passing through the narrow gorges of the Kabul River and the Khyber Pass at 6825 feet, they descend to the town of Peshawar and the Indus Valley. Over this and neighboring routes have come the repeated invasions of India which, in the course of history, have peopled that land with such a variety of races. Until recently, in addition to the dangers and difficulties of the road, the pass was dominated by Afghan tribesmen, who for centuries

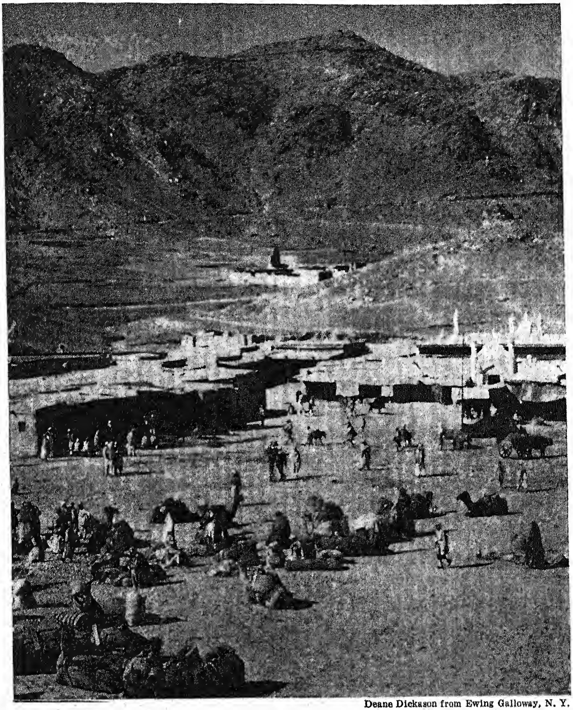

Deane Dickason from Ewing Galloway, N. Y.

FIG. 192. *This village in Khyber Pass is a stopping place for passing caravans*

collected toll from the passing caravans and not infrequently resorted to pillage. Across this series of passes there is no railroad—only a road with steep grades and sharp turns, traveled in large part by loaded bullocks. However, at either end of the pass cities have grown up; Peshawar and Kabul are the two places which are most directly de-

pendent on the Khyber Pass. Farther on, Bokhara is the focus of pass routes, not only from the south but also from the high basins of inner Asia to the east.

Conclusion

In more than a surficial sense mountains are major features of the earth's face. Not only do they stand out conspicuously from their surroundings, but their influence is felt far beyond the limits of this group in the continental patterns of climate and vegetation and in the general arrangement of the occupance. On a continent without mountains the major patterns of the landscapes would be simple; the areal scene could be painted, as it were, with broad sweeps of the brush. But mountains complicate the picture. The differences between the simple patterns shown on the generalized continent (Fig. 51) and the actual patterns on the face of the earth are to some extent the result of irregularities of coast line; but in large part they are the result of the distortion of climatic lines by mountain barriers. These effects are felt beyond the mountain borders: within the mountain regions there is an intricacy of design not equaled in any other parts of the earth. The landscapes are composed of such a complexity of detail that only large-scale topographic studies can reveal their essential qualities. A general vertical differentiation of the landscapes can be discerned, but this fact is obscured in detail by the spotty design of all the landscape elements. It is this remarkable variety of scenery as well as the imposing grandeur of snow-capped peaks against the sky that gives to the mountain lands their fascination.

CONCLUSION

THE INDUSTRIAL SOCIETY

The industrial society is global in its scope and international in its needs. Yet within the industrial society the sentiment of nationalism has risen until it has become essentially a religious faith. "Nationalism is the strongest emotional force in the world today through which the individual is able to transcend his ephemeral self and to become identified with the relative permanence of a self-perpetuating group."[1] The organization of an international society which is essential for the survival of the urban-industrial way of living will be complicated by profound differences of attitude and objective as long as the world is composed of sovereign nation-states. It is hopeful, but inaccurate, to think that these difficulties are similar, and only broader in scale, to those which beset the founders of the United States before the thirteen colonies had agreed to join a federal union. Perhaps it is closer to reality to say that people may be driven to an acceptance of an international order by fear of the consequences of failure.

The technology of the industrial society offers the possibility of better living for greater numbers of people than has ever before been within reach. Large-scale primary production, large-scale manufacturing, and low-cost transportation make it technically possible for human societies to form more efficient connections with the resources of the earth than could ever be formed in past ages. By increasing the production per person through the use of machinery and modern sources of power it is possible to raise the level of living, to increase its security from the effects of local disasters, and at the same time to decrease the number of hours of labor which each person must give for a bare survival. Differences of geography will always remain, for even the theoretically complete operation of the principle of one economic world would not wipe out regional contrasts; there will always be groups which are better off than others; there is considerable doubt whether

[1]Ferdinand Schevill, "Can Our Civilization Achieve a More Stable World Order?" in *The Foundations of a More Stable World Order*, Harris Foundation Lectures, 1940, Chicago, 1941, pp. 3–32.

under the best possible conditions of international co-operation enough of the bare essentials could be produced from the resources of the earth to raise the standards of some of the Oriental countries to what the Occidentals consider to be a minimum. But for a large part of the human species there is hope for economic security.

The invention of methods for the utilization of atomic power is the latest phase of the great revolution in human affairs which started in the eighteenth century. No reliable estimate of the results on human economies of the peaceful use of atomic power can yet be made, but it cannot be denied that the results can be much greater than anything which the industrial revolution has yet brought. At the same time, however, the use of atomic power for purposes of destruction could easily wipe out not only the cities and factories of the world but also all but an impoverished remnant of mankind. These almost incredible alternatives are before us.

The Use of Raw Materials

Already, before the use of atomic power for the production of cheap energy, the industrial techniques of the Occidental world have enormously increased the rate at which the earth's raw materials are utilized. The need for coal, oil, iron ore, and other industrial metals and for fertilizers has increased so rapidly that well within the lifetimes of most of the people who read this book more minerals have been removed from the earth than in all the preceding history of mankind. Not only have the well-known metals, like tin, copper, and iron, been taken from the earth at unprecedented rates, but many new materials, never before valuable, have been exploited for the first time, such as the hardeners of steel,[1] or bauxite, the ore of aluminum (Fig. 193). And in addition to the use of natural resources which are taken from the rock layers of the earth, there has been enormous demand for lumber, for fibers, and for crops which grow in the soil.

One result of the demand for raw materials and of the new means of transportation is the tendency to focus the international demand on

[1]The hardeners of steel, or ferro-alloys, include manganese, tungsten, nickel, chromium, and vanadium.

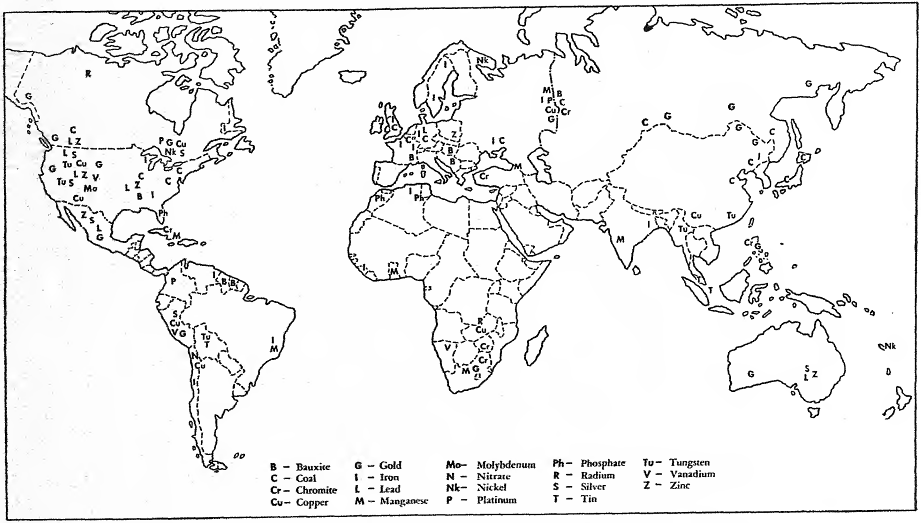


FIG. 193. *Major world sources of certain raw materials*

a very few places. For example, iron compounds are widespread among the rocks of the earth's crust, and iron ore has been mined in a great many places. In the early days of colonial New England the ore which was used to supply the small charcoal-burning foundries was collected from the bottoms of the numerous inland lakes, where a certain type of bacteria had deposited a "bog iron ore." But the demands of modern industry could not be supplied by the small-scale utilization of many scattered sources of iron ore. In order to supply industry with sufficient ore at a low enough cost per ton it is necessary to seek out and exploit the few ore bodies which are extensive enough to permit large-scale operations. A small body of exceptionally high-grade ore might be more costly to utilize than a large body of poorer ore, unless the richness of the ore could compensate for this higher cost.

Actually, during the early 1930's about 90 per cent of all the iron ore produced in the world came from some five localities. The United States produced 40 per cent, chiefly from the mines of Minnesota and Michigan near the shores of Lake Superior and from those of the Birmingham District of Alabama. France and Luxembourg together produced 37 per cent, from ores which came from one ore body shared by these two countries. The Soviet Union produced 7 per cent, chiefly from the Ukraine. The Kiruna District of northern Sweden produced 6 per cent. From these places and from the Bilbao District in northern Spain came most of the vast tonnages of iron ore which the world was using. Important iron reserves still untouched are known to exist in Brazil (over 20 per cent of the world total), Venezuela, Newfoundland, Labrador, and Cuba (Fig. 193).

Coal is traditionally the basic raw material of the industrial society because it is used not only as a source of power but also in the metallurgy of iron and steel. The concentration of coal fields in just a few parts of the world is even more striking than the concentration of iron-ore bodies. Of the world's estimated reserve, the United States and Canada together have 64 per cent, the Soviet Union has 21 per cent, and China has about 4 per cent. Thus these four countries have nearly 90 per cent of the world's coal. Between 1935 and 1939 the United States was mining about 34 per cent of the world's coal production, the United Kingdom was mining 20 per cent, Germany was mining 13 per

Percentage of World Mineral Production from the More Important Sources in 1940[1]

Bauxite		
	France	15.1
	Hungary	15.1
	British Guiana	15.1
	Dutch Guiana	13.3
	Italy	11.4
Coal		
	United States	29.0
	Germany	29.0
	United Kingdom	13.9
Chromite		
	Rhodesia	24.0
	Philippines	15.5
	South Africa	13.1
Copper		
	United States	30.3
	Rhodesia	13.9
	Chile	13.4
	Canada	12.2
Iron		
	United States	35.3
	Soviet Union	14.1
	France	11.8
	Germany	7.1
Lead		
	United States	26.0
	Australia	15.3
	Canada	11.7
	Germany	11.1
	Mexico	10.9
Manganese		
	Soviet Union	50.0
	India	20.0
	Gold Coast	10.0
	Brazil	3.6
Mercury		
	Spain	35.5
	Italy	27.6
	United States	17.1
Nickel		
	Canada	78.7
	New Caledonia	13.8
Nitrate		
	Chile	100.0
Petroleum		
	United States	62.8
	Soviet Union	10.0
	Venezuela	8.6
Phosphate		
	United States	39.5
	Soviet Union	16.5
	Nauru	12.3
Potassium		
	Germany	58.6
	France	15.4
	Soviet Union	10.8
	United States	10.6
Sulphur		
	United States	74.8
	Italy	9.5
Tin		
	Malaya	36.8
	Netherlands Indies	19.2
	Bolivia	16.4
Tungsten		
	Korea	29.3
	China	28.2
	Burma	22.0
	Portugal	11.8
	United States	11.8
	Bolivia	10.2
Vanadium		
	Peru	40.6
	United States	30.7
Zinc		
	United States	37.9
	Germany	13.0
	Canada	10.4

cent, the Soviet Union was mining 9 per cent, and China and Manchuria were mining 6 per cent: 82 per cent of the world's total.

Oil is a raw material of the greatest importance in the modern world,—of greater importance than any other raw material with respect to the operation of the machines of the industrial society. Again

[1] T. S. Lovering, *Minerals in World Affairs*, New York, 1943.

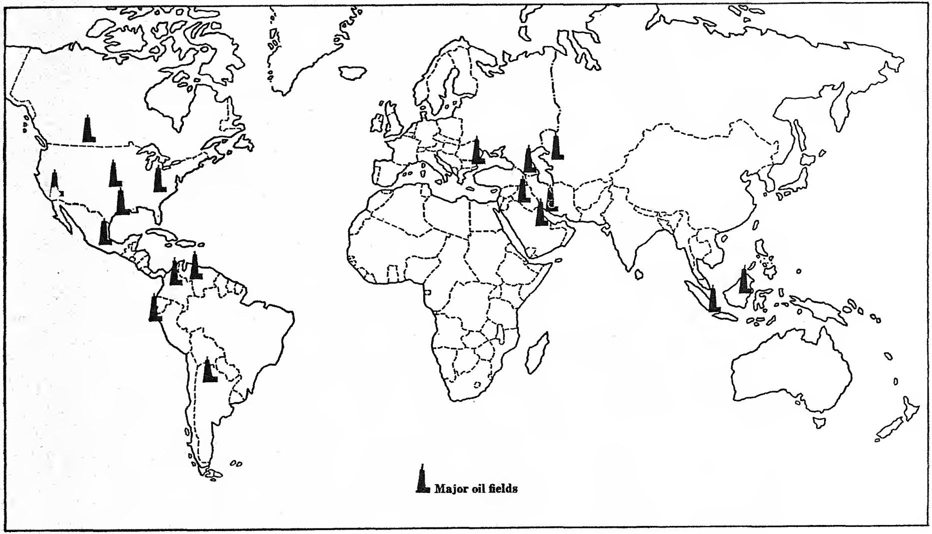


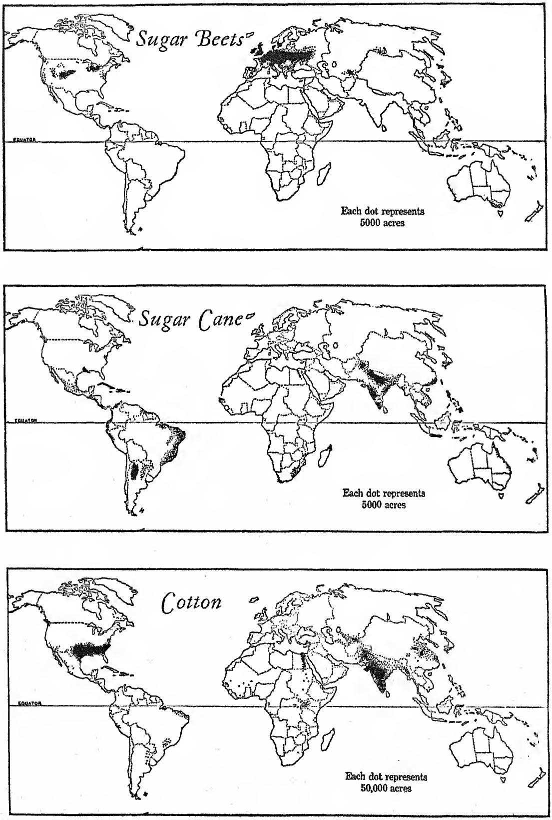
FIG. 194. *Major oil fields of the world*

the United States has been in a singularly favorable position because of the vast oil pools discovered and exploited within its continental area. In the year 1946 the proved oil reserves of the world amounted to some 63,400,000,000 barrels. Of this total about 33 per cent are in continental United States. But the largest known reserve of oil is in the Middle East,—in Saudi Arabia, Iraq, and Iran,—where some 41 per cent of the world total is found. A little more than 9 per cent is in the Soviet Union, chiefly in the Caucasus region, just north of Iran and Iraq. Another large oil field, already one of the chief producers of the world, is in the Maracaibo Lowland of Venezuela. Oil has not been found in large quantities in any other places, although the chances of further discoveries of oil are less predictable than in the case of iron and coal (Fig. 194).

The same principle of uneven distribution and the concentration of production in a few localities is revealed in a study of the other raw materials. The production in 1940 of the more important minerals is shown in the table on page 435. In almost all cases well over three quarters of the production comes from three or four sources. Even in the case of agricultural raw materials which are used for industry the same is true. Most of the world's cotton comes from only seven places, and until the 1930's half of it came from the Cotton Belt of the United States. The other places are the Deccan of India, China, the southern part of the Soviet Union near the Caspian Sea, Egypt, Brazil (São Paulo and the Northeast), and Peru. Most of the world's rubber comes from Malaya and Sumatra. The accompanying maps, Figs. 195–197, suggest the major areas of production of the chief agricultural products of the world.

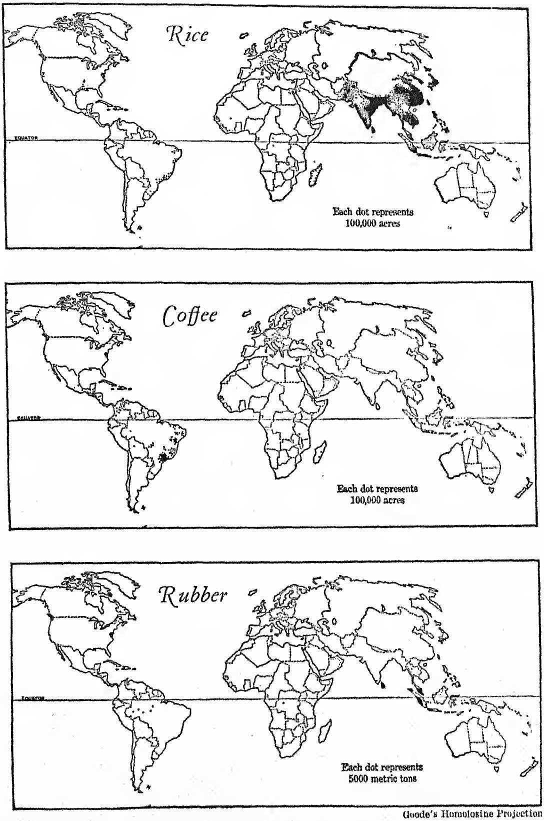
Transportation

Technological progress in the application of controlled inanimate power to transportation is one of the essential features of the rise of the industrial society. The invention and construction of the means of carrying large volumes of all kinds of materials at a low cost per unit of weight has been a major factor in raising living standards in the Occidental world. Not only are the industrial centers supplied with



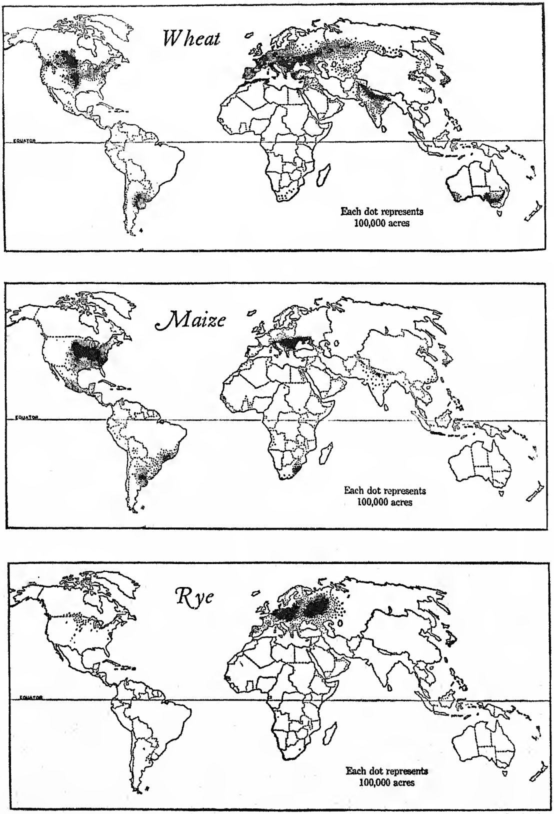
Goode's Homolosine Projection

FIG. 195. *World distribution of sugar beets, sugar cane, and cotton*



Goode's Homolosine Projection

Fig. 196. *World distribution of rice, coffee, and rubber*



Goode's Homolosine Projection

FIG. 197. *World distribution of wheat, maize, and rye*

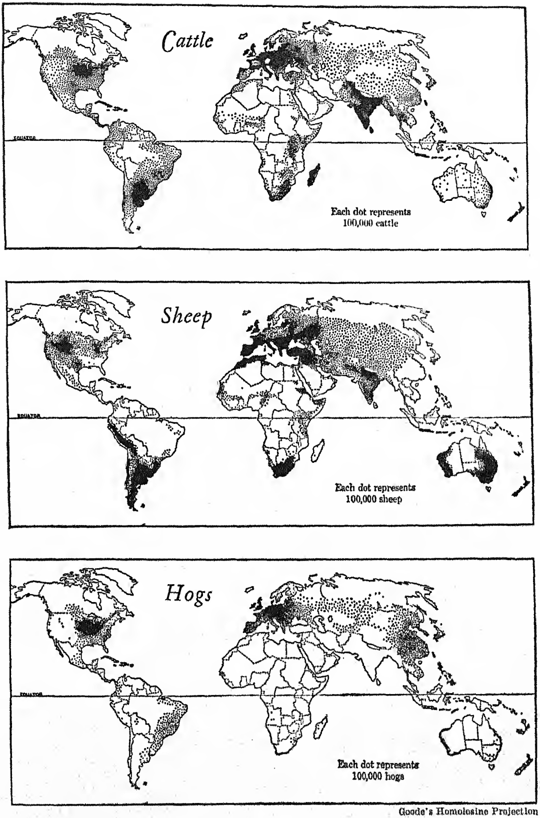


FIG. 198. *World distribution of cattle, sheep, and hogs*

the huge volume of materials necessary for their support, but also it becomes possible for production to localize in those regions or localities where costs are lowest. The differences in kind of production from place to place on the earth is a result, in part, of physical differences of the land, and, in part, of the existence of low-cost transportation and relatively unrestricted international trade. Anything which raises the cost of transportation, or which increases the restrictions on trade across international boundaries, decreases the size and significance of the areas of localized or specialized production in places where goods can be turned out at low cost.

Railroads. The railroad is a distinguishing feature of the industrial society. Mark Jefferson's maps of the continents, on which bands are drawn in white covering about ten miles on either side of a railroad, reveal in a striking manner the centers of the industrial society and the extent to which this society has spread away from these centers (Figs. 73–74). The contrast between the densely populated parts of the Orient and those of the Occident is especially noticeable. There is a fundamental difference between the quality of life within ten miles of a rail line or a paved highway and the quality in places remote from any rail lines and highways; and this difference is by no means wiped out by the spread of air transportation to the remote places.

Highway Transportation. After World War I the importance of highway transportation increased enormously, especially in the United States. The present world distribution of highways passable in all weather for motor vehicles resembles in general the pattern of railroads. The North American area of well-developed transportation, however, shows a closer net of paved roads than does any other major part of the world. In 1940 the United States had over 3,000,000 miles of highway: there were 1029.6 miles of highway for every 1000 square miles of area. At the same time Europe had 858.5 miles per 1000 square miles. The British Isles, however, had 2000.7 miles per 1000 square miles. At this same time the United States had 68.3 per cent of all the motor vehicles of the world, with one vehicle for every four persons. In the British Isles there was one vehicle for every 20 persons.

Ships. Railroads and highways come to a focus on a relatively few large ports, and between these ports ocean ships provide intimate contact. In North America, for example, about half the oversea commerce of the United States moves through New York, Philadelphia, Baltimore, and Norfolk. There is a similar concentration of shipping activity around the North Sea. The greater part of the world's ocean commerce is carried on between these two major areas of the industrial society—northeastern United States and western Europe. But for every ship carrying goods across the ocean there are perhaps four ships engaged in short voyages along the coast, connecting one port with another on the same continent. If all the world's ships could be shown on a large map for any one day, there would be a great concentration off the same coasts which stand out as white on Jefferson's railroad maps. Many of these ships would be sailing along the North Atlantic route between the North Sea and Middle Atlantic ports of the United States; many would also be seen along the Mediterranean–Suez–Red Sea route between western Europe and southeastern Asia and Australia; smaller numbers would be seen on the Southern Hemisphere routes; on vast areas of the oceans there would be no ships at all.

Airplanes. The development of air transportation has forced people to look at world geography with new perspective. The old familiar maps of middle and low latitudes, with north at the top and with most of the high latitudes left out, were good enough for people whose chief means of oversea travel was by ship; yet as a result of the use of these maps the real relations between continents and centers of population were scarcely understood except by professional geographers and mapmakers. If a hemisphere map is drawn with its center in France, it will include what is incomparably the most important part of the earth from the human point of view. In this hemisphere (Fig. 199) is almost 90 per cent of the land area of the world, outside of Antarctica; in it are to be found 94 per cent of all the people of the world and 98 per cent of the world's industries.[1] It is a geographic fact, and not a result of the location of the centers of Occidental culture, that western Europe

[1] J. Parker Van Zandt, *The Geography of World Air Transport,* Washington, D. C., 1944.

Fig. 199. *The principal hemisphere.* (After Parker Van Zandt)

lies close to the center of this "principal hemisphere," and that other parts of the world must be measured in terms of remoteness from Europe. No other great trading area of the world occupies such a central position; 94 per cent of the trading centers of the world are closer to Europe on the average than to any other region of the world. Most of them are within twenty-four hours of flying time from Europe. The world's air routes are much freer to follow great circles than are water routes. Air lines will be drawn between the chief centers of population and production, just as railroads concentrate in these areas; and from these centers long tentacles will be extended to remote places.

The perspective of the world shown by the globe, Fig. 199, indicates that, contrary to some enthusiastic writers, the chief air lines will not cross the polar regions, but will lie on the periphery of these regions. From the chief centers of the United States to the chief centers of Europe the air routes cross Newfoundland or Labrador and perhaps touch Greenland and Iceland; from the United States to the population centers of Japan and China the air routes cross Alaska and northeastern Siberia; directly across the pole from North America are the scantily peopled forests of Siberia and, beyond them, the deserts and mountains of inner Asia. In this perspective of the world South America extends away from the major centers of population and production, and Argentina, at the southernmost tip, is one of the most remote countries on the earth. Only where northeastern Brazil approaches Africa is there a direct air route from Europe to southern South America which does not first cross North America.

Cities

Every remote farm and every rural hamlet in the pattern of Occidental settlement is attached by a road or by some other route of transportation to larger centers, and the larger centers in turn are connected with the great cities. The concentration of people in cities is a major distinguishing feature of the Occident, and especially of the industrial society. In 1940 there were fifty-one cities with more than a million inhabitants in the world. There are 19 such cities in Europe, most of them, as we have seen, in the regions of Group IV. In North America there are 13 great cities. In other parts of the world there are 19. The three cities which stand out above all others are New York, London, and Tokyo.

Urban Functions. People gather together in cities in the Occidental world because certain kinds of activities are better carried on where people are living close together. Some of these activities are economic, some are political, some are social. The two major activities which cause people to live together are the economic ones—commerce and manufacturing industry. Administration is a political function carried

URBAN CENTERS OF MORE THAN A MILLION INHABITANTS[1] (ABOUT 1940)

Europe		*Asia*	
London	8,700,000	Tokyo	7,865,000
Paris	4,963,000	Shanghai	3,499,000
Berlin	4,670,000	Osaka	3,252,000
Moscow	4,137,000	Calcutta	2,488,000
Leningrad	3,191,000	Peiping	1,568,000
Vienna	1,930,000	Tientsin	1,514,000
Manchester	1,750,000	Bombay	1,490,000
Hamburg	1,682,000	Hankow	1,400,000
Budapest	1,585,000	Nagoya	1,328,000
Brussels	1,300,000	Kyoto	1,090,000
Liverpool	1,290,000	Hongkong	1,072,000
Warsaw	1,289,000	Canton	1,043,000
Rome	1,280,000	Nanking	1,019,000
Milan	1,264,000		
Barcelona	1,250,000	*South America*	
Madrid	1,171,000		
Glasgow	1,132,000	Buenos Aires	3,175,000
Naples	1,130,000	Rio de Janeiro	1,564,000
Birmingham	1,090,000	São Paulo	1,500,000
North America		*Australia*	
New York	11,690,000	Sydney	1,398,000
Chicago	4,499,000	Melbourne	1,193,000
Los Angeles	2,905,000		
Philadelphia	2,899,000	*Africa*	
Boston	2,350,000	Cairo	1,312,000
Detroit	2,296,000		
Pittsburgh	1,994,000		
Mexico City	1,757,000		
San Francisco	1,428,000		
St. Louis	1,368,000		
Cleveland	1,215,000		
Montreal	1,140,000		
Baltimore	1,047,000		

on in urban centers. Social activities include education, art, music, religion, and recreation.

These activities are known as ***urban functions.*** They may be classified under four major headings: commerce, industry, administration,

[1]Figures from various sources refer to metropolitan areas not political cities.

and social activities. Each city exists because it performs one or more of the urban functions for a wide extent of territory. *The hinterland* (of a port) or the *umland* (of an inland city) are the service areas for which the urban center performs these functions. A small town may bear a simple relation to the territory it serves, but the larger cities in many cases serve territories which overlap those served by other large cities. This complexity of hinterland and umland is especially great in western Europe and North America where large centers compete with each other for the service of the surrounding country. The principle of the primate city, which was set forth in the chapter on Group IV, states that because the best goods, the largest focus of purchasing power, and the best talents usually find one outstanding urban center in which to concentrate, this one city tends to grow much larger than any of the others. The territory for which cities like New York and London perform the urban functions is essentially the whole inhabited earth.

Some cities perform only one urban function, whereas others perform several or all the urban functions. A *unifunctional* commercial town tends to draw to itself many of the other functions, thus becoming *plurifunctional* as it grows. All the great metropolises are of this sort. But there are some urban functions which are best performed in remote places. Outdoor recreation, for example, may be located at a particularly scenic spot, or a place where there are hot springs or mineral waters. Religious shrines are not usually found in the commercial centers. Certain industries, too, are best located near the sources of raw materials rather than where labor is plentiful or where there is a large market close by. In any case, however, an urban center, whatever its size, should be identified by its performance of an urban function, not by the fact that it has passed an arbitrary limit of size. In the United States urban areas are defined as those having more than 2500 inhabitants; but this is a definition which fits the statistical needs of the census, and which only approximately distinguishes urban from rural communities.

Urban Structure. Occidental cities tend to develop certain characteristic structures. In the study of cities it is necessary to identify and map the areas in which the urban functions are performed; these are known as the *functional areas* of the city. The commercial function is carried

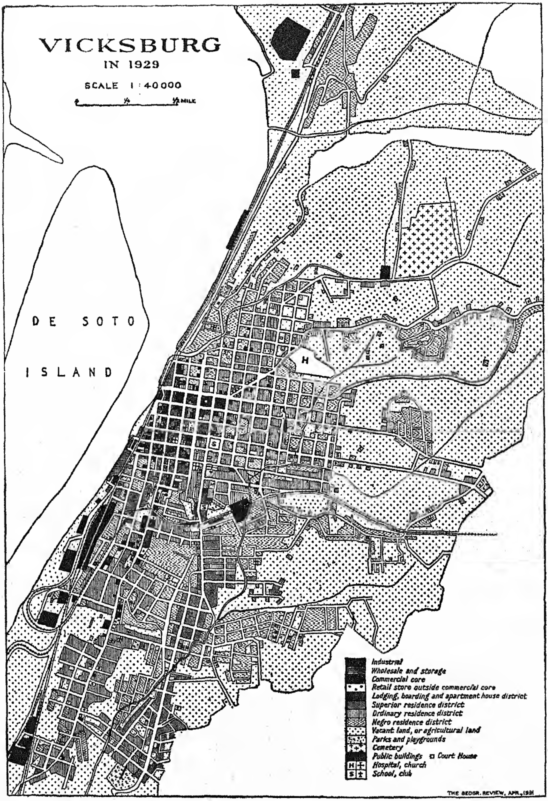
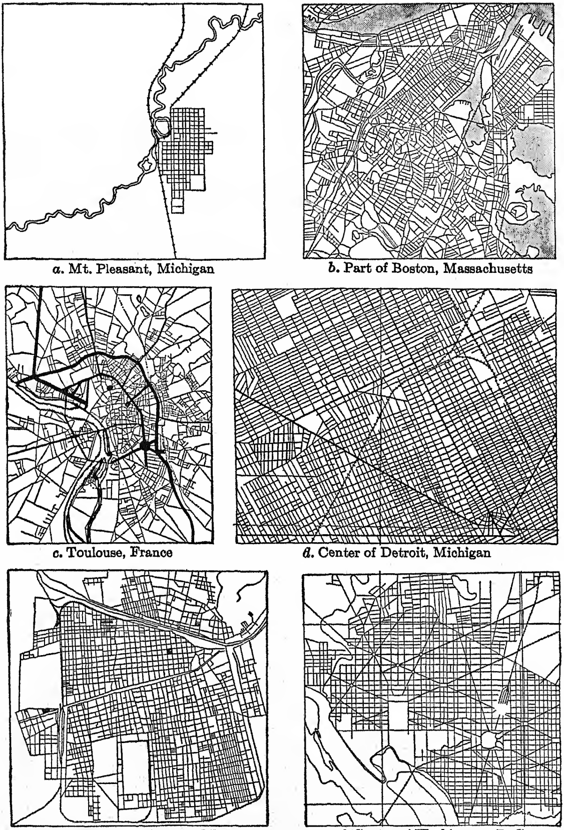


Fig. 200. *The urban morphology of Vicksburg, Mississippi.* (Map by the author; courtesy of the *Geographical Review*, published by the American Geographical Society of New York)

on for the hinterland or umland of a city in the *commercial core*, commonly located in the center of the urban area, or around the port. In North America this part of the city is usually marked by a concentration of tall office buildings. The industrial function is usually scattered in separate units, and in some cases it is even located on the outskirts of the urban area. Around these functional areas there grows up a matrix of residences and commercial or industrial establishments of only local significance—for example, retail stores which serve a neighborhood within the city. Although in general the various parts of an Occidental city tend to form in concentric pattern around the commercial core, the actual pattern of each city, conforming as it does to details of terrain and street or rail pattern, is unique. Not only is the simple circular design in many cities destroyed by the arrangement of the landforms, but the whole pattern is also adjusted to the skeleton of the streets, which, in many cases, had its origin before the growth of the city began. The arrangement of the avenues which converge on the commercial core and of the streets which fill in between the main highways forms the basic design of the urban scene. The accompanying maps (Fig. 201) illustrate some of the variety in the underlying structure of cities resulting from different kinds of street patterns.

Regardless of these differences of pattern, however, the fact is that cities in the modern world are tending to become more and more alike. Not only is this true with respect to their physical appearance but also (and especially) with respect to the way in which city people live and the problems they face. Cities cannot survive if they are cut off from access to the lowest-cost sources of raw materials, or if they are restricted in their access to hinterland and umland. Cities thrive when there is regional specialization of production, for the trade which is thus stimulated flows through the cities. City people who understand what gives them their livelihood cannot fail to support vigorously the concept implied by the words "one world." If one world emerges from the present chaos of conflicting worlds, it is likely to be an urban world.

But one world does not exist today, except as a dream in the minds of those who can think fearlessly into the future. Not only is Occidental culture divided into three separate societies but also the lines of cleavage



a. Mt. Pleasant, Michigan

b. Part of Boston, Massachusetts

c. Toulouse, France

d. Center of Detroit, Michigan

e. Center of Santiago, Chile

f. Center of Washington, D.C.

Fig. 201. *Urban street patterns.* (All maps oriented with north at the top, and drawn on a scale of approximately 1/125,000)

between these societies seem for the moment to be getting sharper and more difficult to cross. And the whole problem of reaching one world is enormously complicated by the continued existence of great aggregates of economic, political, and military power, and of great national sovereignties, among which no basic international law has been as yet widely accepted.

The Great Powers

Three great powers emerged from World War II. These are the British Commonwealth of Nations,[1] the United States of America, and the Union of Soviet Socialist Republics. The first two of these include the part of the world dominated by English-speaking people and by the ideas of the industrial society, which are largely English in origin. The third includes the part of the world dominated by the Communist party, and by the ideas of the soviet society, which are largely German and Russian in origin.[2] There can be no doubt that the only solution for the problem of national sovereignty lies in the acceptance of a world organization in which national sovereignty is at least in part submerged. Not that national loyalty and patriotism should ever be lost; but, rather, that this basic human attitude of group solidarity should be enlightened by an understanding of what is best for the survival and prosperity of the group. In a world of cities and industries capable, as never before, of producing useful things from the resources of the earth, there is no place for the group that wishes to live in isolation.

But national sovereignties still exist. No attempt to provide a geographic basis for the understanding of modern problems would be complete or realistic without an analysis of the significance of the geographic structure of the major political units of the world. It is on the basis of these facts of world distribution that we must go forward, whether to war and disaster or, ultimately, to world organization and peace.

[1]The term British Commonwealth of Nations, as used in the reports of the Imperial Conference of 1926, refers to the self-governing lands of the British Empire. However, the term is used by some writers synonymously with the whole British Empire, whether self-governing or colonial. It is so used in this book.

[2]F. S. C. Northrup, *The Meeting of East and West,* New York, 1946.

THE BRITISH COMMONWEALTH OF NATIONS

Area and Location. The British Commonwealth of Nations differs from the other great powers in that it is geographically scattered over the whole earth (Fig. 202). The original nucleus of the Commonwealth, Great Britain, is very, very small compared with the vast territories in other parts of the world—the dominions and colonies and other possessions which together make up the so-called Commonwealth of Nations. In the original nucleus of England, Scotland, Wales, and North Ireland there are about 94,000 square miles of territory: in the rest of the Commonwealth there are 12,097,000 square miles of territory.

Population. The same fact of wide distribution is apparent in the population of the British Commonwealth of Nations. In the original nucleus there are 49,700,000 people; in the rest of the Commonwealth there are 527,570,000 people—nearly a quarter of all the people in the world.

Attitudes and Objectives. The people who make up the Commonwealth are ethnically and culturally diverse. Even within the original nucleus there are local differences of culture and dialect which loyalty to a common king resolves only superficially. In those parts of the Commonwealth settled chiefly by people from Great Britain there is a common heritage of language and of ideas. Among the ideas the most significant are perhaps three: (1) the right of free speech and majority decision; (2) the right to the private ownership of earth resources and tools and the right to use these for private profit; and (3) the concept that economic values are produced by public demand on a free market. The significance of earth resources in the world of the British Commonwealth is determined by these basic attitudes. Yet more than half the people of the Commonwealth do not wholly subscribe to these ideas, and in some cases do not even understand them.

Resources. The natural resources of the earth have been widely developed by British capital. During the period of the expansion of the Empire the people from Great Britain showed uncanny judgment regarding the parts of the world likely to yield the richest rewards. The

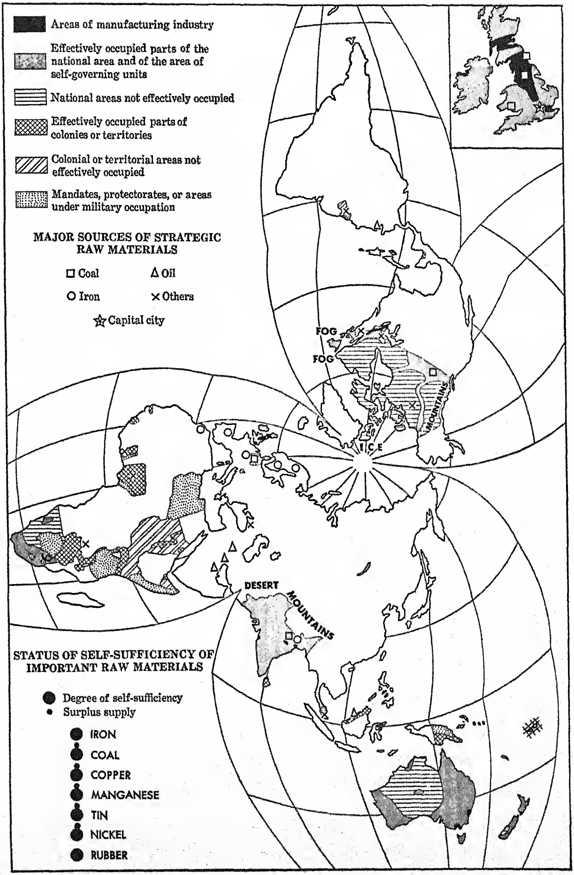


FIG. 202. *Geographic structure of the British Commonwealth of Nations*

regions of Group IV and Group V outside Europe, generally neglected by the other European colonizing nations, were eagerly occupied and developed by the British. Argentina almost became a British dominion, and until recently the domination of that country by British capital was such that its economy was closely tied to that of Great Britain. The British Empire also extended to those other parts of the world where the investment of private capital, without much actual settlement, could bring large returns: as in India, Hong Kong, or the tropical islands and coasts where valuable tropical agricultural products could be raised by the plantation system. In every case, however, the currents of trade which were developed were enormously to the benefit of the people of Great Britain and to a much lesser extent, if at all, to the people of the colonies. Serious problems of population pressure have developed in such places as India, Egypt, and the West Indies; but meanwhile no part of the world enjoyed such spectacular economic development as did the industrial and commercial cities of Great Britain. London became the primate city not of Great Britain alone, but of the whole far-flung Commonwealth.

Within the territories of the British Commonwealth are produced many of the more important raw materials, both mineral and agricultural, but there are certain key items which are lacking. In coal, iron, the hardeners of steel, and tin, the Commonwealth is well off; but it is poorly off in oil, and for this material it must depend on the exploitation of oil in foreign lands such as Iraq and Venezuela. In foods and other agricultural materials the Commonwealth is well off, especially because of the variety of climates in which its widely spread territory is found. It is an old saying that the sun never sets on the British wheat crop: in every month of the year wheat is ripening somewhere in the world for the supply of the urban population of Great Britain. Of special importance are the British possessions on the Malay Peninsula, one of the principal sources of tin and rubber in the world.

Productive Capacity. During the nineteenth-century development of the British Empire, all these varied resources in different parts of the world were discovered, developed, and exploited by British capital. As a result the general level of industrial production increased enormously

in the original nucleus of Great Britain. British manufacturing industries trebled their output between 1860 and 1910. Raw materials were brought to Great Britain in British ships; and the manufactured products were sent to distant oversea markets. London became the financial center of the world, providing the capital for the development of commercially profitable enterprises in every continent.

But in the course of time other commercially advanced parts of the world felt the desire to build their own industries. The United States rose as Britain's major competitor, and during the period when British industrial capacity was increasing three times, American industrial capacity increased twelve times. Also, the British dominions began to recognize the desirability of building their own industrial structures instead of simply supplying raw materials to the home country. Even Argentina arose to declare its independence of Britain's factories. In two world wars the British productive capacity has been decreased, not only relative to the rest of the world but also as compared with prewar capacity. In coal production British output in 1900 was 225,000,000 tons; in 1930 it was 244,000,000 tons; but in 1946 it was only 192,000,000 tons. Coal is a vital element in the British economy because, along with manufactured goods, it provides the exports to pay for the imports of food and industrial raw materials. During World War II it is estimated that the national wealth of Britain was decreased by about 25 per cent. After the war the whole British Commonwealth was producing 18.82 per cent of the world's income. Great Britain was producing 10.50 per cent, and the remainder was being produced in other parts of the Commonwealth. The decrease in coal production was threatening the whole structure of the British economy; for the first time in many years Great Britain was facing a peacetime shortage of food.

Strategic Position. In terms of modern strategy the British Commonwealth has become highly vulnerable. The wide distribution of its parts, which is a source of strength in a peaceful world, becomes a source of danger in a world at war. As long as the British navy remained unchallenged on the sea, Great Britain could maintain its connections with the sources of raw materials from all over the world. The

British life line, protected by Gibraltar, Malta, Cyprus, Suez, Aden, Ceylon, and Singapore, was impregnable. But with land-based air power threatening not only the life line but the giant industrial nucleus itself, the whole strategic situation is changed. Although the figures for the Commonwealth as a whole are impressive, each of the parts—and now even the original nucleus—is no longer in a position to defend itself alone.

The British Commonwealth of Nations, shaken by the destruction of World War II, stands today in a precarious position, its future obviously tied to a solution of the problems of international organization. This original nucleus of the industrial society, perhaps the industrial society itself, cannot long survive a divided and conflicting world.

THE UNITED STATES OF AMERICA

Area and Location. The United States differs notably from the British Commonwealth in that it is chiefly concentrated in one compact territory (Fig. 203). In continental United States there are about 3,022,000 square miles of area; in possessions of the United States, including Alaska, Puerto Rico, and other outlying parts, there is a total of only 597,200 square miles. For this reason alone the attitudes of the American people toward questions of foreign relations must inevitably differ from those of the British.

Population. Most of the population of the United States is concentrated in the continental area. In the forty-eight states the population estimated for 1946 was 142,655,000; the population outside of this area in the same year was 2,870,000, and of this number 2,155,000 were in densely crowded Puerto Rico.

Attitudes and Objectives. The ethnic and cultural make-up of the United States is much more nearly uniform than that of the British Commonwealth. From the British the people of the United States have inherited the same three basic ideas of the industrial society, with the result that for both powers the resources and opportunities of the land have the same meaning. But the United States is not without its

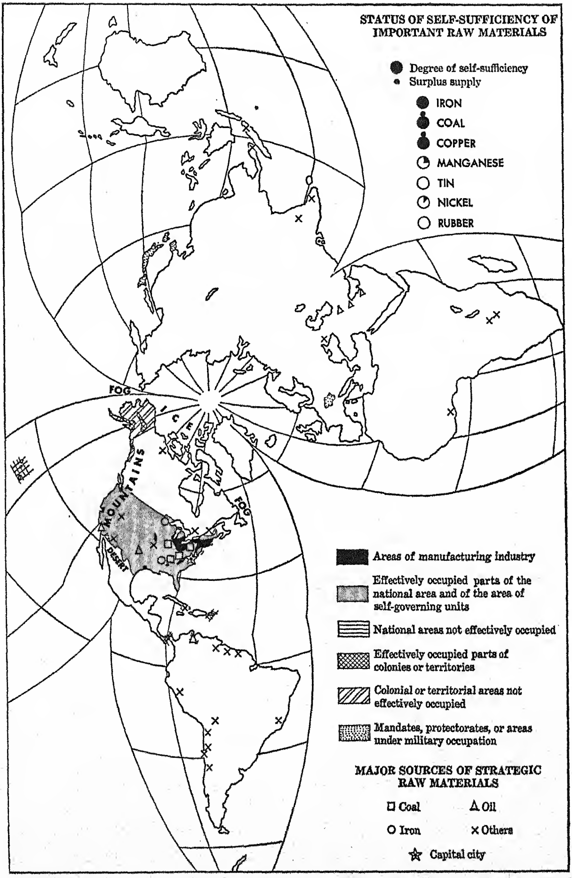


FIG. 203. *Geographic structure of the United States of America*

minority groups which differ ethnically and culturally. Negro and Latin groups, as well as immigrant groups from Europe and Asia, provide serious minority problems not only in the outlying areas but throughout continental United States as well. A considerable proportion of the population in the United States does not wholly subscribe to the three basic ideas, nor are these ideas wholly applicable to them. The proportion of such people, while less than in the case of the British Commonwealth, is of more serious concern to the United States because it involves the nuclear area and not just the outlying parts.

Resources. As we have pointed out in the several chapters of this book, few, if any, parts of the world are so richly endowed with the kinds of resources and lands needed by the people of an industrial society as is the United States. Not only was the territory of continental United States remarkably well supplied with basic raw materials, but the American people were able to create an extraordinary amount of wealth by the unearned increment resulting from the process of settlement, for the land was essentially unoccupied in advance. As settlement progressed across the country, the industrial heart of the United States developed in the northeast, in a highly urbanized area extending from Boston to Washington along the coast, and inland to St. Louis, Chicago, and Minneapolis–St. Paul. The primate city of the United States, New York, has become the largest city in the world.

Within the territory of continental United States are produced many of the more important raw materials, both mineral and agricultural, but there are certain key items which are lacking. No country in the world has such a large proportion of the world's coal reserve as has the United States. To be sure, its enormous iron ore deposits are nearing exhaustion, but other large reserves are available within the Western Hemisphere. The United States is well off in oil; but it is dependent on foreign sources for the hardeners of steel, for tin, and for a number of other essential industrial raw materials. No other part of the world, except the Argentine Humid Pampa, includes land so highly suitable for the production of grain and meat. The Corn Belt of the United States is unequaled in the whole world for the sustained yields of its rich soils and for the large area of its high-grade lands. Yet because of

the position of the national territory of the United States on the climatic pattern of the world (Fig. 51), only a minute part of its area is suitable for the raising of tropical crops such as rubber. For these things, also, it is dependent on foreign sources. To supply the missing raw materials or the materials which may be exhausted in the predictable future, the United States must reach out to Brazil for iron; to Malaya for tin and rubber; to the Middle East for oil so that it can utilize its own reserve at home; and to other parts of the world for raw materials of small total bulk and value, but of essential importance in industry.

Productive Capacity. Even before World War II, the United States was the most productive country in the world, and its people enjoyed the highest standard of living of any large nation. With the productivity of much of Europe destroyed or decreased by the war, the proportion of the world's total income produced in the United States has increased to almost 50 per cent. In 1946, while Great Britain was producing 192,000,000 tons of coal, the United States produced 520,000,000 tons; while Great Britain was producing 7,800,000 tons of iron, the United States produced 41,000,000 tons. Because of the renovation of manufacturing equipment during World War II, the productive capacity of the United States, unlike that of Great Britain, was greatly increased. The productivity of labor in terms of output per man-hour gained approximately 20 per cent. In the postwar world there is great need for the products of industry: need not only in parts of the world actually devastated by war but also in the many substandard areas of the United States itself. However, a large proportion of mankind is too poor to pay the cost. The solution of this dilemma involves much more than the profits of the owners of capital: it involves inevitably the very survival of the free institutions of the industrial society.

Strategic Position. The United States is not so vulnerable as is the British Commonwealth. It has the advantage of a vast area which would make actual invasion difficult and costly. And even in the age of air power and atomic weapons, no conflict can be concluded until the territory of the defeated country is occupied by the victorious army. But air power and atomic weapons have greatly changed the signifi-

cance of the geographic position of the United States. Because the productive heart of America is concentrated in great urban centers in the northeast, it is peculiarly exposed to attack and serious damage. The protection afforded by wide expanses of ocean under the effective control of a friendly power can no longer be counted on to preserve the United States from immediate contact with the destructive force of modern warfare.

The attitude of the people of the United States on questions of foreign policy was shaken by World War II. There was a sudden awareness that the country could not hope to exist in isolation. The principle that an industrial society cannot exist in isolation even in times of peace is still not widely understood; but people now realize that in time of war they are no longer invulnerable. Many Americans, looking at the geographic relations across the polar regions for the first time, are beginning to think in terms of a round earth, not of an earth made up of separate continental islands. The United States possesses enormous power, basically because of its geographic position, its wealth, its productive capacity, its command of potential resources, and the technical genius of its people. But can this power be used so wisely and in accordance with such high moral principles that this country can lead the way to world peace and to a new world order? In the American system of free institutions and popular government, this leadership can depend not on the rise of one great statesman, but only on the intelligent and informed currents of public opinion in which everyone has a share of the responsibility.

THE UNION OF SOVIET SOCIALIST REPUBLICS

Area and Location. The Union of Soviet Socialist Republics differs from the other great powers in that all of its territory makes up one continuous geographic area (Fig. 204). There are 8,500,000 square miles of Soviet territory, and an indefinite number of additional square miles of dominated territory in eastern Europe and northern China; but there are no oversea possessions. Furthermore, this great expanse of land area lies farther to the north than does the territory of the United States: its position on the generalized continent places it mostly north of the

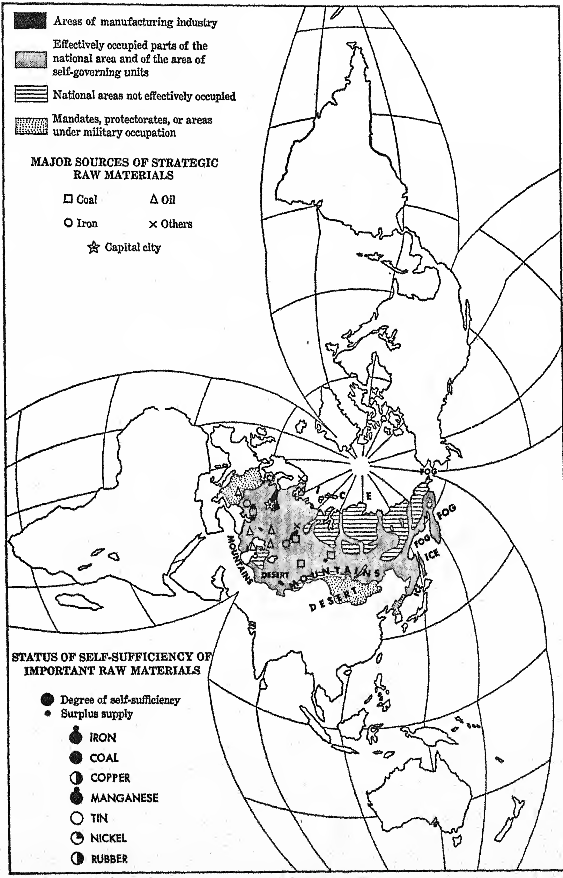


Fig. 204. *Geographic structure of the Union of Soviet Socialist Republics*

dry lands, and mostly outside the regions of Group IV (Fig. 51). Moreover, most of its coasts are frozen and inaccessible in winter, except for those along the Black Sea.

Population. The population of the Soviet Union in 1946 was about 193,215,000, or approximately the same as the combined populations of Great Britain and continental United States. But because of the relatively large proportion of young people in the Soviet population it is estimated that by 1955 its numbers will have reached 210,000,000, whereas the United States and Great Britain will have 152,000,000 and 50,700,000 respectively. By 1970 the population of the Soviet Union will be much greater than that of the other great powers combined.

Attitudes and Objectives. The people who make up the Soviet Union are ethnically and culturally diverse. About 58 per cent of the total are Russians. Ukrainians make up another 16 per cent. The remaining percentage is made up of many different ethnic and culture groups. In the revolutions of 1917 and 1918 an essentially pre-industrial society was abruptly brought under the control of the Communist system, and the soviet society, based on the ideas of Karl Marx, was brought into being. With respect to the three basic ideas of the industrial society, the soviet society thinks along entirely different lines: (1) free speech and majority decisions can be enjoyed only by those who accept the basic premises of Communism, and dissident elements within and outside the country are to be removed not by persuasion, but by whatever means seem most expedient; (2) the ownership of earth resources and the tools of production rests with the government, which acts for the people but is not of them or by them; (3) economic values are determined not by demand on an open market, but by the proportion of the total socially necessary labor which was devoted to the production of the particular commodity. Obviously, for people whose basic habits of thought are so different as are those of the soviet society and those of the industrial society, words do not have the same meanings, and the elements of the physical land do not have the same significance.

Resources. What are resources, then? Certainly not something that can be developed for individual profit. The only cost accounting must

be in terms of work expended; there is no reason to suppose that, because it would be uneconomic for people of the industrial society to develop certain mining activities, or to plant certain kinds of crops, or to build industries in certain locations, it would also be uneconomic in the soviet society. The attempt to understand the operation of the soviet economy must therefore be about as difficult for us as it would be for a Russian to understand the operation of a capitalist economy.

Even with this difficulty of understanding, however, it is possible to say of the Soviet Union that within its territory are produced many of the more important raw materials, both mineral and agricultural, but that there are certain key items which are lacking. The Soviet Union possesses sufficient coal for its needs, even if the reserves are not so impressive as are those of North America. It also possesses large supplies of iron ore and of two of the hardeners of steel—manganese and chromium. It is well off in oil, but with proved reserves which seem to be less than those of the United States. In the black-earth belt extending from the Ukraine into southwestern Siberia the Soviet Union possesses agricultural lands of great productivity, but subject, more than those of North America, to the shortness of the growing season. There are, however, key minerals and key agricultural products which the Soviet Union lacks. It has no rubber, no tin, no tungsten, and by no means enough of the things which must be grown in the warmer parts of the earth, such as cotton. If the Soviet Union desires to build modern industrial plants and to use these plants for the kinds of goods needed by the people, it must also gain access to the sources of raw materials in other parts of the earth. Even in a soviet society the technical needs of industry are such that they can be supplied only from the whole world.

Productive Capacity. Building on the miserable productive capacity of Czarist Russia, the government of the Soviet Union has accomplished marvels of economic growth. To be sure, a large part of the productive capacity of the pre-war Soviet Union was destroyed by the German invasion, but this is being rapidly improvised again by machinery taken in reparations from defeated European countries and from Manchuria. Soviet heavy industry is being rebuilt in the Donetz Basin, north of the Sea of Azov, where the great Ukrainian reserves of coal, iron, and

manganese can most effectively be brought together, and where abundant hydroelectric power can be supplied from the big dam on the Dnepr River. Yet, in spite of very great effort on the part of the people, the proportion of the total world's income produced in the Soviet Union is small—only 6 per cent.

Strategic Position. In many ways the strategic position of the Soviet Union resembles that of the United States. The invulnerability given by vast area has been demonstrated a number of times, notably by both Napoleon and Hitler. Yet the airplane has reduced the significance of this invulnerability, just as it has in the case of the United States. The productive heart of the Soviet Union lies fairly close to the southern border—to Turkey, Iraq, and Iran. Therefore, quite aside from the oil resources of these countries, the Soviet Union would like to control them for security reasons. But there is still another reason: the Soviet Union has inherited from Czarist Russia the frustrated desire for a warm-water port, for without such a base no naval power could be maintained. Relatively invulnerable as the Soviet territory may be from the point of view of invasion, it is also, for this very reason, difficult to emerge from the national territory. Only by the conquest of western Europe, China, or the Middle East can the Soviet Union reach ice-free water. In so far as the Soviet Union hopes to remedy its difficulties by physical conquest, the quest for access to the ocean must remain a major interest.

The World's Population

While the great powers face one another across national boundaries, the arrangement of earth resources and of population in the world as a whole bears scant relation to the political areas into which the world is divided. The inescapable geographic fact, on which all plans for the solution of the world's problems must rest, is the uneven distribution of resources and peoples.

The Measurement of Population Density. The issues involved in population problems are often obscured by the common custom of

measuring population density with reference to political areas. Entirely erroneous conclusions can be reached from the comparisons of density per square mile for such large areas as the Soviet Union, the United States, or Australia. In the last-named country, where a very large proportion of the land is too arid to support any considerable number of settlers, the over-all figures give no real understanding of the facts of population density in the settled areas.

A much more significant figure can be found by measuring the population against the number of square miles which can be used for crops or pasture. The following table presents these figures for the United States, Great Britain, and the Soviet Union.

Population	*United States*	*Great Britain*	*Soviet Union*
Density per square mile of total area	46.2	529.1	22.7
Density per square mile of arable and pasture land	109.9	658.1	64.4

In discussing the population density of any country, it is therefore necessary to distinguish between the *total national territory*, or the total area within the political boundaries, and the *effective national territory*, or that portion of the total political area which is actually used for the support of the people. Only in the case of small countries which are wholly utilized are these two figures the same.

Still more meaningful figures can be derived from a more careful and precise study of the relation of people to the land. For even within the effective national territory there are great differences in the forms of land use, and the density should be measured in relation to the area occupied by each form of use. Only in this manner can any real understanding of the population problems be gained. This, however, requires detailed geographical field studies which, for many parts of the world, are not available.

Population Pressure. What is population pressure? What population density marks the beginning of "overpopulation"? From the survey of various parts of the world we understand that population pressure is an exceedingly complex phenomenon which cannot be

measured simply in terms of density. It can be presumed that population pressure begins when any considerable proportion of the inhabitants find themselves unable to achieve a minimum standard of living. What that minimum standard is depends on the attitudes, objectives, and technical abilities of the people. There are certain parts of the world—for example, parts of California for the maize-eating Indians—which suffered from population pressure when the number of people per square mile was very low. Population pressure began for the Eskimos when Europeans introduced the rifle into their nicely balanced hunting economy. In the industrial society population pressure begins in the densely crowded cities when there are large numbers of chronically unemployed people. The solution must be found in one of three ways: (1) by widespread famines and epidemics which reduce the population; (2) by emigration, which in countries with high birth rates has no permanent effect; or (3) by changing the attitudes, objectives, and technical abilities of the inhabitants.

Urbanization and Rates of Growth. The population pattern of the world is not a static thing. The present-day map is one in a series which comes to us out of the past centuries and can be projected on into the future. The present areas of great concentration are relatively recent in world history, and they could be considerably changed in the centuries to come.

We have seen that as each region or country changes from a society characterized as predominantly rural to one which is predominantly urban a clearly marked succession of events takes place. At first the birth rate is high, and so also is the death rate. With urbanization and the development of manufacturing industries, the death rates decline; and since birth rates remain high the net result is a very great increase in the total population. But even when death rates are continuously lowered by modern medicine and by better diet, the birth rates also are lowered until population growth gradually levels off. Eventually the population becomes almost static, but at a greatly increased level of density. This demographic cycle has been completed in most parts of western Europe, and its conclusion in the United States lies within the predictable future. It is just starting in the Soviet Union; and its

arrival among the already densely populated Oriental countries is awaited with concern.

At the present time the fastest-growing region of the world is Latin America. During the twenty years from 1920 to 1940 the total population of Latin America increased about 41 per cent; in the same period the population of the United States increased only 25 per cent. Although there are signs that this rate of growth will decrease after 1970, it seems likely that by the year 2000 Latin America will be occupied by at least 300,000,000 people; whereas the predicted population of the United States at that time lies between 130,000,000 and 200,000,000.

Certain parts of Latin America are rapidly becoming urbanized. In Argentina, for example, 40 per cent of the inhabitants live in cities of 25,000 or over, which is the same proportion as in the United States. The industrial society is developing rapidly in Argentina, in São Paulo State in Brazil, and in parts of Mexico. In these urban centers the rapid increase of population is due to migration from the rural areas to the cities; already birth rates in the cities are notably lower than those of the rural areas.

Migration. The population of the world in past centuries has been rearranged by migrations. The concentration of such large numbers of people in the Group IV regions of western Europe was the result of migrations from both the centers of earlier civilizations in the warmer parts of the world and also from the grassland regions of the interior of Eurasia. The movement of Europeans to other continents, especially to the Americas, was a major event in the long history of mankind. The enforced movement of Negroes from Africa to the Americas created serious problems of race relations that have yet to be solved. The migration of the Chinese into Manchuria involved many millions of human beings. In the great majority of cases the migrants were seeking better economic opportunities.

The movement of people into the United States during the nineteenth and early twentieth centuries resulted in the most rapid growth in total population ever achieved by any large part of the world. In 1775 there were only 2,500,000 people in the colonies; and to the west the whole expanse of the continent as far as the Pacific Ocean was

only very thinly occupied by Indians, fur trappers, and Spanish cattle ranchers. The westward movement of the frontier across first-class lands, accompanied by the extension of the railroads and by the growth of industries in the eastern cities, created not only great wealth in the form of increasing values of property but also that characteristic American attitude of optimism in the face of apparently insuperable obstacles. The arrival of millions of immigrants from Europe supported and maintained this movement. They came to America because it was a land of opportunity; and because they came, it was a land of opportunity. But many Americans naïvely assume today that nothing but laziness, softness, or weakness of purpose keeps a similar migration from creating similar values in other parts of the world which are still relatively empty.

The fact is that changes in technology since the early years of this century have greatly altered man's relation to the land. There is still need for a larger production of the basic necessities of life from the farm, the mine, and the quarry. But new technology makes possible the low-cost production of these things through the use of machinery. On the farms, fewer farmers could raise more wheat for the world at lower cost; but modern mechanized farms require large capital investment at the same time that they need fewer man-hours of labor to operate them. The day when there was great economic opportunity for the small farmer on the agricultural frontier has gone. At present the greatest economic opportunity is in the cities, and it is to the cities, all over the world, that people would migrate if they were given the chance.

The Basic Problem. And so we return to the basic problem of man on the earth. We find that the distribution of people is the result of complex forces operating in societies whose basic values are in process of change. We can interpret the significance of the elements of the land when we understand the attitudes, objectives, and technical abilities of the people; but predictions in a period of rapidly changing culture are especially difficult. It is essential to avoid the assumption that changes will not continue.

Are the resources of the earth sufficient to support the growing

number of people in the world? No clear-cut answer can be given for an equation in which there are so many unknown and unknowable factors. Can unrestricted private enterprise, developing the new technologies profitably, provide the flow of low-cost goods necessary for the support of some two and a half billions of people? There are many who think it cannot be done. Can the soviet society find the way to utilize effectively the technologies discovered and invented by science and engineering? There are many who think that this is not the way out. The problem does not seem quite so incredibly difficult if we consider the plans for the next few decades within the region or even the community. But plans which are drawn up on the theory that the region or community can exist in isolation will prove faulty. The existence anywhere in the world of large numbers of impoverished people will tend to lower the standard of living in all other parts of the world. Modern technology, which gives the opportunity to produce useful things from earth resources at rates never before imagined, also brings all the world's people closer together than ever before. Ultimately the solutions which are found to be workable will be in harmony with the uneven distribution of the world's resources, and they will be for the benefit of all the world's people.

APPENDIXES

A · MAPS

By Hibberd V. B. Kline, Jr.

1. The word "cartography" by its derivation means the making or drawing of maps or charts. To the geographer it is the content of maps that is significant. The full and accurate understanding of content must, however, be based on sound knowledge of the advantages and limitations inherent in cartography. These are related to the basic considerations of space and distance, to map "projections" which present the spherical form of the earth on a two-dimensional surface, and to symbols which stand for facts and ideas.

2. **The Map as a Tool for Analysis and for Synthesis.** The cartographical method serves the geographer as a tool or instrument for analysis. On the map he can record any phenomena, physical or cultural, which are observed on the face of the earth. It must be remembered that the framework upon which these facts and inferences are plotted is that of the earth, or a part of the earth, itself. The geographer may derive his data from original observation in the "field," which in a sense is his laboratory, or from secondary sources. No matter what the derivation, he plots his information on the map. It is thus reduced to comprehensible size and concreteness. The cartographical method also serves the geographer as a means of synthesis and generalization. By use of the map he may combine two or more phenomena for study, or present their relationships to each other. The map is a method of summing up spatial phenomena that have two or three dimensions. The geographer, whose interests are in the significance of differences from place to place, therefore finds the map to be both a means and an end in his field of study.

I. Basic Requirements of a Map

3. **Direction.** We may consider the map to be a representation of the earth itself or of selected items that have areal distribution over the earth. To be more than a diagram or picture, a map must show meas-

urement of distances, and position or direction with reference to the points of the compass. Direction may be represented in several ways, all of which are based upon a convention commonly accepted by all the nations of the world today. That is, direction is given with reference to an imaginary grid related to the axis of rotation of the earth. This grid of latitude and longitude gives the four cardinal directions of N. E. S. and W. and permits direction from any given place to be considered in terms of arcs of a circle, according to any of the systems for dividing a circle. Direction, then, becomes a matter of stating how a line drawn on the face of the earth trends with relation to the grid of the earth or to a circle drawn around some point on that line. Direction in a circle is measured in terms of an arc, or azimuth.[1]

The instrument most commonly used to determine direction is the compass. Since the magnetic compass conforms to the magnetic lines of force of the earth's field, which is not in perfect correspondence with the axis of rotation of the earth, a correction must be applied in most places to convert magnetic readings to azimuths, or to bearings.

4. **Scale.** Distance is based more simply on a direct comparison between linear measurements on the earth and on the map. A map that is the same size as the portion of the earth it represents would be similar to a pattern used by a dressmaker or toolmaker. Maps are not patterns and are therefore, without exception, smaller in size than the size of the corresponding segment of the earth. It is obvious that a ratio must exist between a linear measurement on the earth and its facsimile on the map. This ratio is *scale*. Any distance on the map is taken as unity, or 1. The corresponding number of units which this same distance has on the map provides the remainder of the ratio (or the denominator to the numerator of 1). Thus a scale of 1:10,000 is a ratio in which one unit on the map (in inches, centimeters, spans, pipestems, or any other measurements) equals 10,000 of the same units on the earth. A scale of 1:1 would be "pattern-size." A scale of 1:100,000

[1]Azimuth is stated in degrees from 0° to 360°. Two systems are in common use, reading clockwise from either the north or the south point. Bearings are stated in quadrants (quarter circles), using the nearest meridianal point and the direction from it. For example, S. 75° E. is the bearing of azimuth 105° (from north point) or azimuth 285° (from south point).

is ten times *smaller* than 1:10,000 because the unit on the map stands for 10 times as many units on the ground. Scale may be written as a fraction (1/10,000), sometimes designated as R.F. or representative fraction. Scale also may be expressed in words that translate the ratio of like units into other equivalents. For example, a scale of one inch to one mile has a ratio of 1:63,360 (viz. 5280 feet in one mile $\times$ 12 inches in one foot $=$ 63,360 inches in one mile). Therefore, if one unit is one inch in the numerator, the 63,360 units in the denominator equal one mile. Scale may be expressed also as a line drawn on the map and divided into distances representing the distances on the earth. This is an appropriate convention because it makes measurement possible by direct comparison with the subdivided line.

It must be emphasized that scale is a linear comparison between map and earth. The greater the disparity between these two measurements the smaller is the scale. This may be readily appreciated and remembered by recalling that $\frac{1}{2}$ is larger than $\frac{1}{4}$, and thus 1:10,000 is larger than 1:100,000. Areal comparisons between scales, in accordance with the principles of geometry, are in terms of the squares of their linear measurements. Thus, in the last example above, the linear difference is 10 times but the areal difference is 100 times, since area implies the measurement of two directions at right angles to each other.

5. **Position.** The third attribute that makes a map, that of position, is a consequence of distance and direction, and it is often expressed in terms of the other two (so far in such a direction from a known point). Absolute position may be stated as an intersection of the geographical grid lines in terms of latitude and longitude[1]; for example, Washington National Observatory 38°55′ N., 77°04′ W. Other systems

[1]Latitude is the distance north or south of the equator expressed in degrees from 0° at the equator to 90° at each pole. Lines measuring latitude extend east and west around the earth parallel to and including the equator. These lines, therefore, are "parallels of latitude." Longitude is the measurement of distance east and west on the earth. Since no obvious starting point for such measurement exists, an arbitrary line must be selected. Many such "prime meridians" have existed, but today the meridian of Greenwich, England, is commonly accepted as zero. The north and south "meridians" marking the intervals of longitude are numbered from the prime meridian westward to 180° and eastward to 180° to complete the circumference of the earth.

of co-ordinates may be used, such as the town and range systems of the U. S. Land Survey (see Fig. 116); the arbitrary co-ordinates of a military grid; and the network lines on an atlas page.

A map, then, is a representation of the surface of the earth, or some portion of it, in which directions, distance, and position are shown as truly as possible, or with sufficient accuracy for the purposes of the representation. That perfect representation from a mathematical point of view is impossible will be demonstrated subsequently.

II. Measurements for Mapping

6. Base-Line and Triangulation. Maps have their origin in the measurement of the earth. Since most maps either are concerned with the land and water bodies of the earth, or relate their subject matter to this distribution, it is apparent that this primary distribution must be determined. The precise determination is known as surveying. The basic concepts of surveying are simple, although the exact methods and applications may be exceedingly complex. Surveying is based on straight lines. A straight line is most easy to sight along, to measure, and to draw. Therefore, direction (line-of-sight) and distance (along the line) may be simulated by a proportionately smaller straight line drawn upon a piece of paper or map. The place where two or more straight lines intersect is a fixed position, which also may be plotted upon the map.

Surveying, or sighting along straight lines, takes two fundamental forms. The first is the *traverse*, in which, starting from a known position, the direction and the distance is measured along each of a succession of straight lines. Points of positions not on these lines may then be related to this framework by additional straight lines drawn and measured to them. The second method is *triangulation*. In this method the measurement of angles takes the place of the measurement of lines, except that at the beginning a *base-line* must be measured carefully. Triangulation makes use of the triangle, or three-sided geometrical figure. Given the measurements of the angles of a triangle and the length of one side, the lengths of other sides can be determined by the simple trigonometry to which virtually every school child in the Occi-

dental culture is exposed. Thus triangulation is the building of triangles in which the directions of the sides are known and the distances are computed after measuring the angles between sides. It has an advantage over the traverse in that many observations can be made from one point and in that the tedious and exacting measurement of lines is avoided, save for the necessary base-line. This method, like the traverse, supplies a framework of known lines and positions to which other detail can be added by further sighting and measurement.

Complexities are added to these simple methods by the fact that instruments are not perfect and man is not infallible; by the irregularly oblate spheroidal shape of the earth, which introduces problems of spherical trigonometry; by the influences of gravity and magnetism, which differ from place to place; by the presence of vegetation, atmospheric refraction, and other handicaps to observation; and by the irregularities in altitude and slope that occur on the surface of the earth.

7. Elevation. The measurement and mapping of the surface irregularities of the earth require that some point be chosen to which to relate places of higher, lower, or equal elevation. This point is most often the ocean at some aspect of its level (as "mean sea level" or "lower low water"), and the point is transformed into a geometrical figure of area to become the "datum plane." Since the distance from the center of the earth to the surface of any ocean is affected by gravitational differences from place to place, and since all of the oceans have differing "levels," the altitudes obtained from different datum planes are not directly comparable.

Elevation with reference to the datum plane is measured by a procedure called "leveling." Leveling consists of determining the altitude of points the horizontal position of which is known by surveying. The method is to measure the distance between points and their differences in vertical angle from each other. This may be done with a number of different instruments for measuring these two elements. In the United States the telescopic alidade and the leveling rod are commonly employed. The former is focused on the latter. The number of marked intervals on the rod intersected by the cross hairs in the lens of the telescope gives the distance. The angle of the instrument focused on

the rod is given by a measuring arc in terms of degrees of elevation or depression from the horizontal. The two figures entered into a table give the difference in elevation between the known position and the new position. The map representation of differences in elevation and the form of the surface require the use of symbols.

8. The techniques of surveying and of leveling have been modified and supplemented, but not supplanted, by photography—both terrestrial and aerial. It is possible to take pictures of the land surface and from those pictures to construct the horizontal and vertical measurements of a portion of the earth. However, photographs alone will not suffice, for they must be related to positions established by work on the ground. This use of surveying and of leveling establishes "control points" by which the pictures can be oriented and be corrected for the irregularities of scale and other errors inherent in pictures. Aerial photography, in particular, has captured the imagination because of the rapidity, precision, and relatively low cost with which work may be done. The quality of aerial surveying, however, can be no better than the control upon which it is based.

III. Map Projections

9. **The Properties of Map Projections.** Reduction of measurements made on the face of the earth to scale representations on the map is a simple procedure provided that only a few square miles of the land surface are involved. Areas of greater extent are more complex because the curvature of the earth's surface and the flat plane of the surface of the map are different geometric forms. The whole earth, or any major segment of it, cannot be simulated to scale except by a globe or a part of a globe, any more than a ball or other round object can be flattened without distortion. By acknowledging and understanding this distortion, the earth spheroid can be represented on a plane surface. This is the *map projection*[1] in which the geographical grid (latitude and longitude lines) of the earth is systematically arranged on a plane

[1]The term "projection" is in good repute even though most projections are mathematically computed and are not true perspective arrangements of the geographical grid "projected" onto a geometrical figure.

surface in order to achieve some desired qualities or properties. The properties that may be obtained are:

a. Conformality (orthomorphism), in which *shapes* of limited areas on the earth are truly represented on the map. This quality results from right-angle intersection of meridians and parallels on the map (as they are on the earth) and the same scale along these lines (not necessarily the true scale) at the intersection. Obviously this quality cannot be applied to a large area, but ingenious approximations are possible.

b. Equivalence (equal-area), in which the ratio between any area on the earth and the corresponding area on the map is constant. This quality is obtained by adjusting the spacing of parallels and meridians so that the area enclosed by any quadrilateral composed of these lines is of the same size proportionally to the similar area on the earth, as is any other quadrilateral. Equivalence applies to the whole map, although shapes must be distorted on any equal-area map in order to keep areas in the same proportion to the earth everywhere.

c. In conjunction with either of the above properties, another quality known as *azimuthal* (or zenithal) may be obtained. Azimuthal projections are those in which direction is truly represented from the center of the projection.

d. Some projections fail to possess any of the above properties, but are *compromises* which sacrifice exactness in order to attain the approximate appearance of the earth, or part of it.

The variety of map projections that it is possible to construct is almost infinite. However, a limited number of projections are commonly used. The following pages are devoted to those which are commonly encountered, although two pure, but extreme, perspective forms of little actual significance are used to introduce some of the principles involved.

10. **Cylindrical Perspective Projections.** The basic concept of the "perspective" projection is that the geometrical figure upon which the geographical grid is "projected" must be developable. That is, the figure must be one that can be flattened out into a plane surface without distortion. One such figure is the cylinder which, after cut-

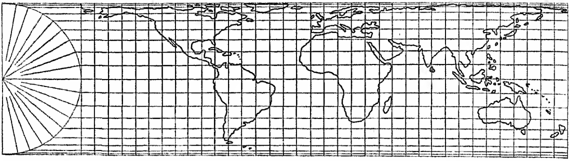


FIG. 205. *Cylindrical equal-area projection*

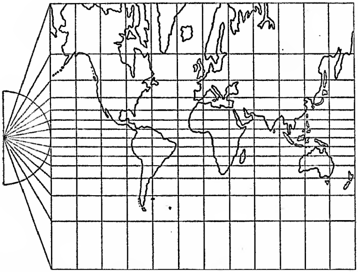


FIG. 206. *Central cylindrical perspective projection*

ting, may be unrolled. A paper cylinder may be wrapped around a globe representing the earth, and the geographical grid may be transferred from globe to paper. If a paper cylinder tangent at the equator (the usual case) is of the same height as the diameter of the globe, and if it is intended to represent the whole globe, then a map projection such as Fig. 205 is obtained. This is the *cylindrical equal-area projection*, in which the lines of perspective are assumed to come from infinity as parallel lines. Clearly the equator is truly represented, since the length of the equator on the globe is the same as on the tangent cylinder. However, the poles, which on the globe are points, are elongated by this perspective projection into lines the same length as the equator. This results in great east-west stretching in high or polar latitudes as well as crowded parallels. Observe that half the circumference of the globe is compressed into the distance representing the length of the

diameter of the globe, and that the spacing between parallels decreases away from the equator. This projection, then, is so objectionable in high latitudes as to be little used.

The cylinder of paper may once more be wrapped tangent to the equator of the globe, and the origin of the perspective lines transferring the geographical grid to the paper may be placed elsewhere. If the origin be placed in the center of the globe, *the central cylindrical perspective projection* shown by Fig. 206 results. Once again the equator is truly represented, but obviously the poles can never be shown, since they lie parallel to the tangent cylinder. High latitudes are so grossly exaggerated in area and shape that this is hardly a satisfactory projection.

11. **Mercator.** Using the ideas contained in the above projections, it is possible to construct other cylindrical projections that do have significance. Gerhardus Mercator in 1569 published one which bears his name. It had great significance in the age of exploration by sea, and it is the best known projection today. It is also most commonly misunderstood. Mercator compromised between the cylindrical equal-area and the central cylindrical perspective projections by spacing the parallels not according to any perspective arrangement but mathematically, so that expansion of the area north and south of the equator is at the same scale as expansion east and west in any given latitude. For example, the parallel of 60° latitude is, on any cylindrical projection, just twice as long as on the earth, and 80° latitude is six times as great. Mercator made his distortion in the N.–S. direction in these same proportions. The projection is, therefore, conformal, but of increasing scale and decreasing fidelity of larger shapes away from the equator; and the poles cannot be shown (Plate 7).

The Mercator projection owes its fame to the fact that a *straight line* upon it cuts all meridians at the same angle and is a *rhumb line*, or line of true compass direction.[1] It is not necessarily the shortest line between

[1] A line of true or constant direction on the globe that trends in one of the cardinal directions (E. W. N. or S.) is a straight line since it is a parallel or meridian of the geographical grid. Any line trending in any other direction must cut across the geographical grid and, on the globe, follows a spiral path, or *loxodrome*, which curves toward the nearest pole, but theoretically never reaches it. The spiral path of the loxodrome may be demonstrated by drawing a line on the globe that everywhere trends northeast, for example.

two points on the earth (unless they are on the same meridian or both are on the equator), but it is one the direction of which is easily ascertained, and also it can be steered by compass in a ship or airplane. Therefore, navigators generally use the Mercator map or chart to determine their direction of movement. *Great circles*, or shortest routes between widely spaced points, are often approximated by traveling along a series of rhumb lines obtained from the Mercator projection, rather than trying to steer a constantly changing compass course. The Mercator projection has obtained the sanction of established use to such a degree that it is often misused where equal-area projections or other projections of the whole world would be more appropriate. Much confusion over the size and positions of areas on the earth, such as the relative areas of Greenland and South America (compare Fig. 211 with Fig. 206) or the idea that North America is located between Europe and Asia arise from the inappropriate use of the Mercator projection.

12. **Elliptical Projections.** The tangent cylinder lends itself to other perspective and mathematical projections.[1] A related class consists of those oval or elliptical projections of the whole earth in which the meridians are not parallel to each other, but are less widely separated toward the poles. In these projections the diameter of the globe forms the N.–S. axis, while the E.–W. axis is taken as twice this value. This relationship of distance from pole to pole, being one half the distance along the equator, is the same as on a globe and is the basis for equality of area. Three equivalent projections on this scheme are shown in Figs. 207, 208, and 209. *Mollweide's homolographic* and the *Sanson-Flamsteed sinusoidal* projections both possess meridians equally spaced on the parallels, and the latter are truly parallel as on the globe. They differ from each other in that the homolographic diminishes the interval between parallels toward the poles, thereby expanding E.–W. the shapes of the lands in the high latitudes; the sinusoidal expands the interval between parallels toward the poles, thereby contracting the E.–W. extent of lands in high latitudes. The *Aitoff* projection (Fig. 209) effects a compromise by departing from

[1] O. M. Miller, "Notes on Cylindrical World Map Projections," *Geographical Review*, Vol. 32 (1942), pp. 424–430.

the parallelism of the parallels of the globe. Despite the curved parallels, equivalence is maintained by decreasing the spacing of the meridians toward the margins of the projection. The result is a pleasing projection in which shapes of land areas are well shown.

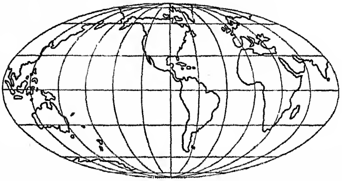


Fig. 207. *Mollweide projection*

13. A drawback to all the oval projections is that only the areas adjacent to the central meridian have good shapes. One solution is to lengthen the points that represent the poles to lines parallel to, but not as long as, the equator. Such projections are those of *Eckert* and *Denoyer's semi-elliptical.* They may be made equivalent or conformal, but they introduce their own errors of shapes, for, obviously, the poles cannot truly be shown as lines.

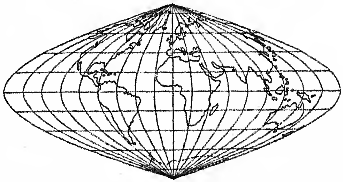


Fig. 208. *Sanson-Flamsteed projection*

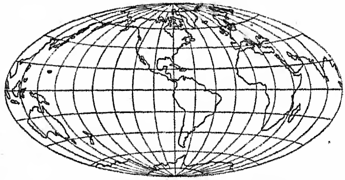


Fig. 209. *Aitoff projection*

14. A second rationalization consists of "interrupting" the world projections so as to create several central meridians around each of which is plotted a segment of the geographical grid. This reduces the errors of shape very materially while retaining equality of area. Carried to its extreme, these interruptions would be the "gores" of paper with which an inexpensive globe is covered (Fig. 210). One interrupted projection is *J. Paul Goode's homolosine* projection. Close

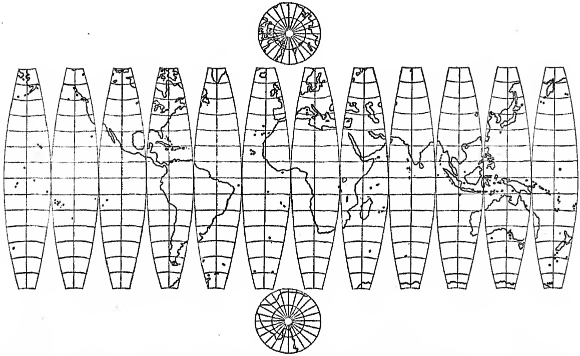


FIG. 210. *Gores for a globe*

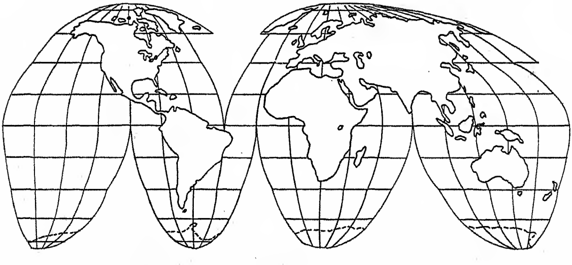


FIG. 211. *Goode's homolosine projection*

examination of Fig. 211 will reveal that Goode has used Mollweide's homolographic projection from 40° to the poles, and the sinusoidal between the equator and 40°, in order to get the best shapes for each area, and that he has "interrupted" the oceans to maintain the continents as units. Another edition of this projection interrupts the continents to give continuity to the oceans. V. C. Finch has provided a useful interruption of the Aitoff projection by eliminating some of the landless

areas of the earth and fitting the Australian–New Zealand segment into the position normally occupied by the Indian Ocean (Plate 22). A common reaction to these interrupted projections is objection to the fragmentary appearance of the geographical grid. Once it is appreciated how the various fragments fit, the realistic shapes and equivalent areas must be acknowledged to be an advantage over other world projections.

The sinusoidal projection is used in this book with a three-lobed interruption (see Fig. 143). The lobe containing Europe and Africa uses the central meridian of 20° E., but the other two segments each have a different central meridian north of the equator from that south of the equator because the land mass of South America is distinctly east of North America and the center of Australia is about 40° east of the approximate center of Asia.

15. **Projections to a Plane.** Another group of projections is derived by the perspective extension of the geographical grid from a globe to a plane that is tangent to that globe. Since a plane is used, and not a cylinder, only one half or less of the earth can be depicted. Moreover, these projections are azimuthal, since all great circle lines that pass through the tangent point (center of the projection) are straight lines and therefore directions are truly shown from the center of the projection. Three points are commonly chosen as the origin of the perspective lines: infinity, to produce the *orthographic projection*; the circumference of the globe at the point diametrically opposite the tangent plane, giving the *stereographic projection*; and the center of the globe, called the *gnomonic projection.* These projections may be prepared in three different forms or cases: *equatorial* (*normal*), with plane perpendicular to the equator; *polar*, with plane perpendicular to the pole; and *oblique*, with the plane in some intermediate position.

16. The orthographic projection shows considerable compression of the marginal areas of the hemisphere (Fig. 212), just as perspective lines from infinity compress the high latitudes of the cylindrical equal-area projection. However, this is a useful projection because it has approximately the appearance of a globe, viewed from a distance, or a photograph of a globe. It is not exactly the same because neither the human eye nor the camera is at infinity.

17. The stereographic projection (Fig. 213) has a geographical grid which expands away from the tangent point. It is conformal, but exaggerates areas near its margins so that it is not in common use for an entire hemisphere.

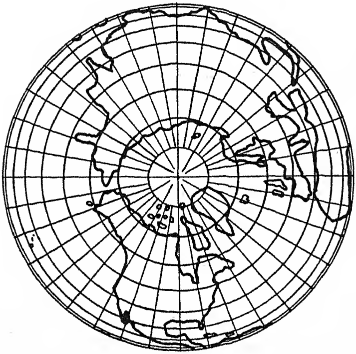


Fig. 212. *Orthographic polar projection*

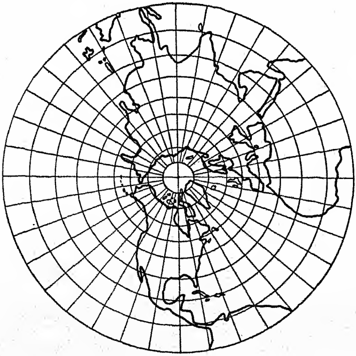


Fig. 213. *Stereographic polar projection*

18. On the gnomonic projection (Fig. 214), with perspective lines derived from the center of the globe (similar to the central cylindrical perspective projection), the margins of a hemisphere cannot be shown since they lie in a plane parallel to the tangent surface. Indeed only a small part of a hemisphere can be shown without excessive expansion of shapes and sizes of areas. There is one unique property of the gnomonic projection which makes it useful in spite of its obvious defects. This is the fact that all straight lines drawn on the projection are great circle routes (i.e. great circle or circumference lines on the globe become straight lines on the projection). It is therefore possible for the navigator to determine

readily the shortest distance between two points by plotting them on the gnomonic chart and connecting them with a straight line. Points along this line can be transferred to the Mercator chart (where they will form points on an arc unless they lie wholly on the equator or on a meridian) to obtain azimuths or directions (rhumb lines) by which to steer to approximate a great circle course.

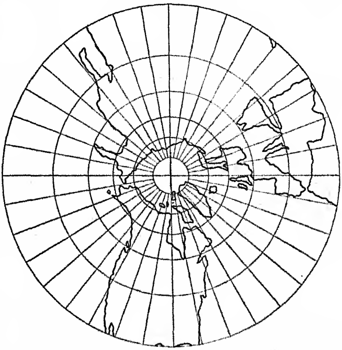


FIG. 214. *Gnomonic polar projection*

19. The principle of the tangent plane may be used with the perspective lines originating elsewhere than stated above. It also may be followed in mathematically locating the geographical grid without recourse to perspective. Two well-known projections of the latter type were constructed by the French cartographer Lambert in the 18th century. *Lambert's Azimuthal Equal-Area* projection gives satisfactory shapes to large areas of approximately equal dimensions and is therefore well adapted to use for continents, as in the plates in this book (Plates 13 and 19 are in the equatorial case; Plates 15 and 17, the oblique case). It is sometimes employed for hemispheres, but here the distortion of the peripheral areas becomes noticeable as in Fig. 199.

20. The *Lambert's Azimuthal-Equidistant* projection derives its name from the fact that any line drawn outward from the center of the projection not only has a true azimuth but also is true to scale throughout its length (Figs. 156 and 157). Since these are the two properties desired, shapes and areas cannot be considered important, and the projection may be extended to contain the whole world within its circumference. If this projection be plotted around the north pole (Fig. 215), Antarctica occurs everywhere around its periphery, since all directions

are south from the north pole and must inevitably lead to the south pole; and, on this projection, the south pole is at its true scale distance—the radius of the projection. If plotted around a point between pole and equator, both poles will be shown as centers from which the geographical grid curves and loops outward (Fig. 216). This projection has practical value, for example, to radio engineers, since radio waves travel along straight lines outward from the center of propagation.

FIG. 215. *Azimuthal-equidistant polar projection*

21. Conic Projections. When map-makers and map-users are interested in areas of less than hemisphere proportions, they may employ parts of the foregoing projections or they may turn to a series of projections based on the concept of another developable geometric figure placed tangent to the globe. This new figure is the cone, which is a surface intermediate between a cylinder and a plane and may be "unrolled" to become a plane. Commonly the apex of the cone is considered to lie on the polar axis of the earth extended into space, so that the cone is tangent to a selected *standard parallel.* Following the analogy of the cylinder, this parallel must be of true length and scale, since it is a line on the globe and the cone both. When the cone is unrolled and opened out into a plane surface, the standard parallel becomes an arc of a circle. All *other* parallels remain parallel to the standard parallel and are therefore concentric arcs on the map projection. The meridians are straight lines radiating outward from the apex of the cone.

In its simplest form, the conic projection is derived by perspective from the center of the globe so that the parallels are unevenly spaced,

becoming farther apart away from the standard parallel. The ordinary *simple conic projection* has the parallels equally spaced at an arbitrarily chosen interval, and is particularly suited to areas of middle latitudes

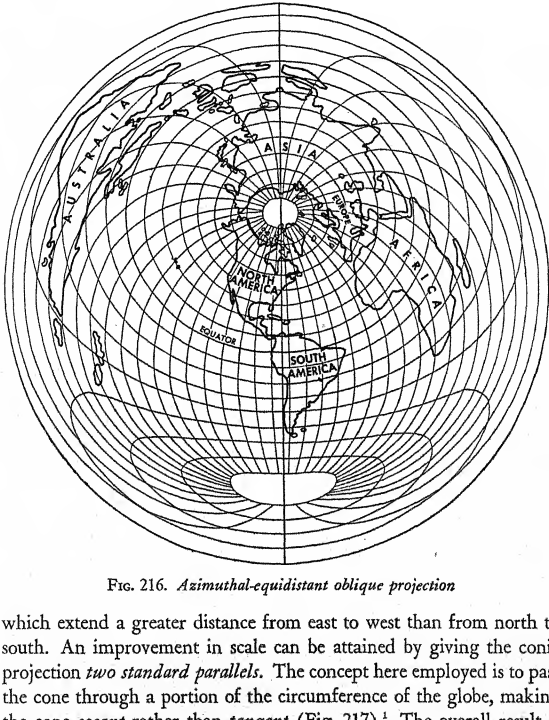


Fig. 216. *Azimuthal-equidistant oblique projection*

which extend a greater distance from east to west than from north to south. An improvement in scale can be attained by giving the conic projection *two standard parallels.* The concept here employed is to pass the cone through a portion of the circumference of the globe, making the cone *secant* rather than *tangent* (Fig. 217).[1] The overall result is

[1]Obviously a cylindrical projection also may be constructed secant to the globe, rather than tangent. Such a projection, for example, is Gall's Stereographic in which the parallels of 45° N. and 45° S. become standard parallels, true to scale.

better, since scale errors are reduced, but none of the conic forms below are either equal-area or conformal.

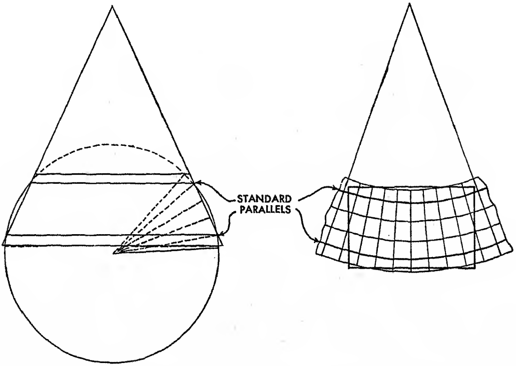


FIG. 217. *Conic projection with two standard parallels*

22. To add either of these desirable properties to conic projections with two standard parallels it is necessary to space the parallels to get quadrilaterals proportionately the same as on the globe, or to space the parallels so that scale along parallel and meridian is the same at their intersections. The former spacing is known as *Alber's Equal-Area* projection and may be recognized by the fact that outside of the standard parallels the spacing of other parallels decreases. The latter is *Lambert's Conformal Conic* projection, and its parallels are increasingly wider apart beyond the standard parallels. Once again, these conic projections are best adapted to areas extending primarily east and west. By careful selection of the standard parallels, either projection will give a map of the United States, for example, with very little scale error.[1]

[1]Both of these projections have been calculated for the United States by the United States Coast and Geodetic Survey. Alber's Equal-Area, with standard parallels at 29½° N. and 45½° N., has a maximum scale error at 1¼% in the United States. Lambert's Conformal Conic with standard parallels at 33° N. and 45° N. is 2½% off at the maximum, within the United States.

23. The simple conic projection may be modified in other ways than the above. *Bonne's projection* (Fig. 218) is commonly encountered in atlases for continental areas having the north-south axis longer than the east-west (North America or South America, for example). The equally-spaced concentric arc parallels are retained, but the meridians are curved so that they meet at the pole, rather than extending as straight lines meeting in space at the apex of the cone. The spacing of meridians on the parallels gives quadrilaterals of true proportion to similar ones on the earth, and thus the projection is equal-area. Shapes are good along the straight central meridian only.

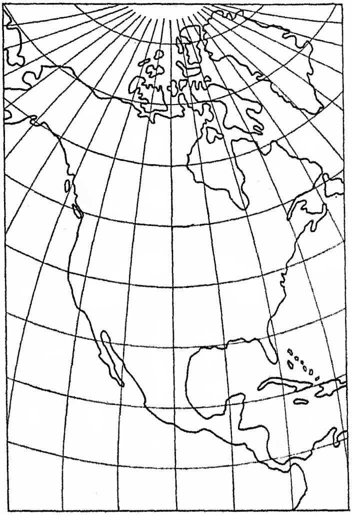


Fig. 218. *Bonne's projection*

24. Another modification of the conic is particularly well known to Americans because it is the projection used for the detailed maps of the United States comprising the "Topographic Atlas," issued in the form of the familiar quadrangle sheets. This is the American polyconic projection in which not one but a whole series of cones are considered to rest tangent on the globe, each at a different parallel but with their apexes in a common line. Each parallel then is an arc of a circle, but the circles have different centers so that the arcs are not concentric to one another. Meridians drawn through the parallels at their true scale positions will yield one straight central meridian and the remainder curved (Fig. 219). Since the principle is one of adjustment

northward and southward along many parallels representing many cones, this projection is best suited for areas of great length in those

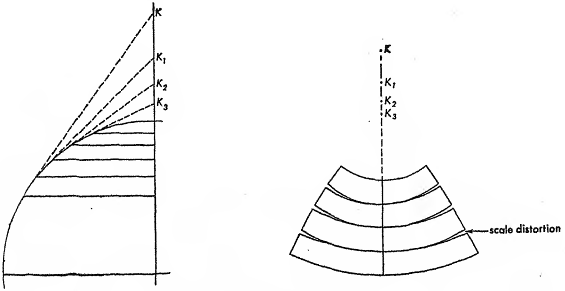


Fig. 219. *Polyconic projection*

directions and of limited east-west extent. Although the polyconic projection is neither equal-area nor conformal, its use for quadrangle sheets has been firmly established, probably because of the ease of construction from published figures.[1] At the publication size and large scale of the quadrangles, it is not easy to recognize the lack of equivalence or conformality on an individual sheet. A disadvantage of the American polyconic is that sheets lying along the same parallels will not fit together except by distorting the paper, although any number may be placed in a N.–S. line with perfect coincidence of margins.

25. The International Map of the World at the scale of 1:1,000,000 is divided into sheets 6° in longitude and 4° in latitude. It is on the Lallemand Polyconic projection in which the familiar principle of two standard parallels is employed for each sheet and for each of the many cones. This projection also uses straight-line meridians with two standard meridians on each sheet. This device permits each sheet to be independently adjusted to one of the secant cones, yet to fit against the margins of the adjacent sheets north, south, east, and west. Obviously the Lallemand projection is a compromise and is neither equal-area nor conformal.

[1]United States Coast and Geodetic Survey, Special Publication No. 5.

26. The catalogue of map projections is by no means exhausted by the projections named above. Some additional manipulations take the following general forms:

a. Projections onto geometrical figures other than cylinder, plane, and cone. The figure may be a cube or other polyhedron. The geographical grid may be arbitrarily spaced within a conventional surface such as a circle.

b. Turning the cylinder or cone so that the developable geometrical figure is "skewed" with relation to the geographical grid. Examples are the *Transverse Mercator* and the *Transverse Polyconic,* in which the "good parts" along the equator of the Mercator and along the central meridian of the polyconic are given other orientations. Bonne's projection becomes *Werner's* when the tangent cone is fitted across the pole instead of along a parallel. *Werner's projection* becomes *Goode's Polar Equal-Area projection* when interrupted (see Fig. 1).

IV. Map Symbols

27. It has previously been stated that maps are selective representations of facts of distribution. This is true even of the topographic map, which shows a small area at large scale, because all the manifold aspects of the earth's surface cannot be depicted. The usual combination of selected features on topographic maps falls into five categories:

a. The surface configuration, including form, elevation, and relief.[1]

b. The drainage pattern, including running water, standing water, and permanent ice.

c. The material works of man, including his settlements, structures he erects, transportation ways he builds, and other facts of his land utilization.

d. Certain invisible aspects of man's use of the land such as political boundaries and air routes.

e. The conventions of the map such as geographical grid, borders, index numbering, and so forth.

Sometimes a sixth category consists of the vegetation cover.

[1]See definition of relief given on page 88.

Obviously the category of invisible facts can be represented on the map only by means of symbols. It is less obvious perhaps, but just as true, that all the other categories also require symbols. How can a railroad track 4′ 8½″ between rails be drawn to scale, with ties, ballast, and switches? How can a stream be shown that changes its course, its width, and its volume? How would you draw a hill? The use of symbols or conventions that stand for given facts is imperative. The quality and accuracy of a topographic map depends on the selection of data and their symbolization.

The symbols commonly used on the United States topographic maps are depicted in Fig. 220. Those that represent point locations or linear distributions require no explanation, for they are generally a stylized portrayal of a tangible fact as seen from a vertical position,[1] or an arbitrary representation of an intangible. However, surface configuration has a broad two-dimensional aspect that is difficult to symbolize and a third, or vertical, dimension that must be shown and is even more difficult to present on the two-dimensional surface of a map.

28. **Representing the Vertical Dimension.** An oblique (nonvertical) photograph such as that taken out of a window of an airplane shows the vertical dimensions of the land by the principles of perspective, but scale obviously changes away from the camera, and objects are obscured by both distance and intervention of other objects between them and the camera. The cartographer may render a similar "pictorial" impression of relief. He may adjust distance and scale by changing his position with reference to perspective from place to place on the map. However, he must always displace some portion of the landforms from their true positions and obscure some areas by that displacement, in order to show height and depth. The high volcanic cone of Fujiyama in Fig. 184, for example, is drawn from an oblique view, whereas the urban areas of Yokohama and Tokyo are seen from a vertical position. The realistic effects of this map by Guy-Harold Smith, or of the "physiographic method" used so effectively by Erwin Raisz (see Figs. 9, 10, and 13 and many others in this book) may com-

[1]This fact will be appreciated by noting that the marsh symbol is viewed from a horizontal position.

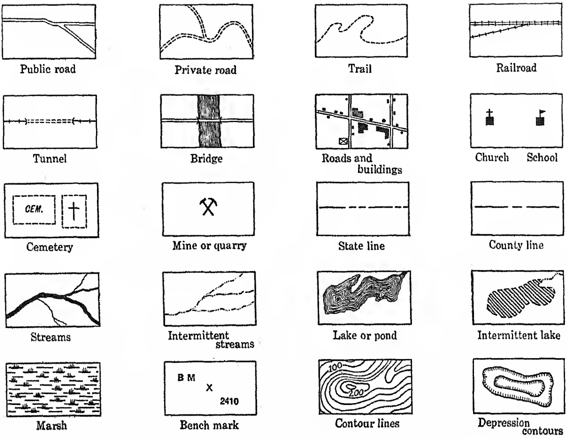


FIG. 220. *Symbols on U. S. topographic maps*

pensate for the errors inherent in an oblique view. The physiographic method is, of course, a symbol system because each type of land surface is represented in a particular way, rather than as an individual unique form.[1] If each mountain were drawn as exactly as possible, which of the numerous oblique views would be representative of it?

29. The vertical aerial photograph gives some impression of surface forms by the distribution of light and shadow. Unless the contrasts are strong and the relief of the surface is great the nature of the surface may not be readily recognized. This is a common disadvantage of photomaps. Indeed vertical photographs must be used in stereographic pairs[2]

[1]Erwin Raisz, "The Physiographic Method of Representing Scenery on Maps," Geographical Review 21 (1931), 297–304. A considerable degree of realism characterizes the use of these symbols in that the drainage pattern is closely followed, as well as the trends of uplands and changes in slope.

[2]A pair of photographs which have some part of their area in common but are photographed from different angles so that when placed in a stereoscopic instrument (or properly viewed by the unaided eyes) they produce a three dimensional image.

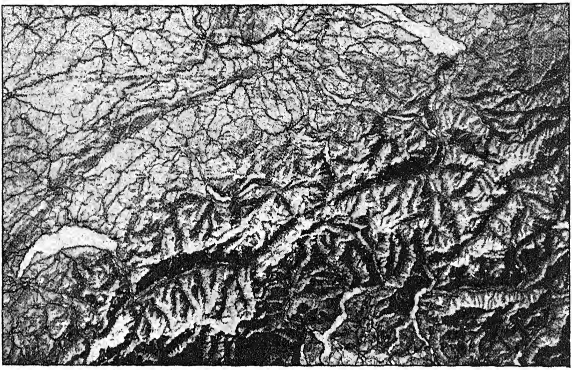


FIG. 221. *Plastic shading with oblique illumination.* (From map of Switzerland by Kümmerly and Frey)

in order to measure slope, height, and relief. The cartographer may employ light and shadow more effectively than most photographs to give the appearance of the vertical dimension on a two-dimensional surface because he can select the amount and the angle of illumination. This method is called plastic shading (as in Fig. 221, which should be compared with Fig. 190). It is not susceptible to measurement, unless combined with some other form of relief representation.

30. A more measurable employment of light and shadow is known as the hachure system. Hachures are short lines drawn vertical to the steepest slope, thin lines representing gentle slopes and thick lines representing steep slopes. In the Lehman system, slopes of 45° or greater employ hachures so close together that they merge into solid black masses. Hachured maps are difficult to draw and difficult to make measurements from, although the effect of relief is pleasant to the eye, particularly when combined with light and shadow effects (Fig. 222). High and flat areas may be difficult to distinguish from low and flat areas, and absolute altitude must be indicated by figures.

31. While all the above systems have their peculiar merits, cartographers more commonly employ another system, particularly for maps of topographic quality. This is the contour line, which may be defined as an imaginary line on the surface of the ground everywhere at the same elevation above the datum plane for vertical measurements. Successive contour lines above and below each other are separated by an arbitrary contour interval. In reading a map employing contour lines it is mandatory that we know the contour interval as well as the exact elevation of the lines. Since a contour line is everywhere throughout its length parallel to the datum plane, it neither rises nor falls in elevation, and it must, if traced far enough, come back to close with itself to form an endless line. No two contour lines may touch each other, since they are separated by a contour interval, although a vertical or overhanging cliff because of the horizontal position of the lines printed on the map will cause the contours to join or cross each other.

Fig. 222. *Hachuring with oblique illumination.* (From the Dufour map of Switzerland)

The way in which certain surface features are represented by contour lines is shown in Fig. 223. Certain basic rules for the interpretation of contour lines are:

a. Contour lines are continuous and do not branch or cross.

b. If a contour line closes upon itself within the area of the map, the land slopes upward from the area outside to the area within the enclosure. Therefore, a group of more or less concentric closed contour lines represents a hill.

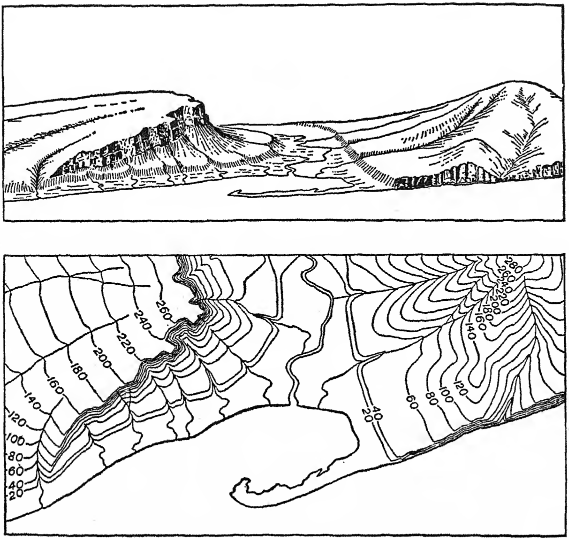


FIG. 223. *A relief sketch and its contour map representation*

c. Contour lines bend when they approach a stream valley so that the bend in the line points in the upstream direction. Relations of valleys to contour lines may be seen in the radial drainage pattern around Mount St. Helens in Fig. 173.

d. Contour lines that enclose depressions which have no outlets at the altitude of the contour lines must be specially marked in order to reveal that the enclosed area is lower (see rule *b* above). This marking usually is in the form of hachures pointing downslope drawn along the contour lines, at right angles to the lines.

e. Some map producers emphasize particular lines (for example every fifth line) by greater width of line in order to guide the eye through the complexities of many adjacent lines.

When properly selected as to contour interval and width of line in relation to the scale of the map and the relief of the area, contours may give a very excellent *visual* impression of the configuration of the surface. Where the contours are bunched together the slopes are great and, if the contour lines are irregular, the surface is rough. Where the contours are closed and concentric the reader sees ridge tops, hilltops, and mountain ranges. Areas of widely spaced contours are low in slope and may represent plains, valleys, or broad upland surfaces according to their relationships to other features. Thus, the qualitative characteristics of the surface may be read almost at a glance and with about as full comprehension as provided by any other symbol system. Quantitatively, it is possible to read altitude within the limits of the contour interval. Spot heights may be used to supplement the value of the lines. It is also possible to determine the vertical relief between two or more points. Horizontal distances being known, the calculation of slope is possible. The contoured topographic map, then, is favored by engineers and others who must have quantitative data. Some geographers and physiographers have transformed contour maps into relative relief and average slope maps.[1]

32. **Quantitative and Non-quantitative Data.** The principle behind the contour line has been applied to the representation of quantitative data on maps. These lines are called *isarithms*, or lines of equal value. Examples of isarithms are furnished in the field of climatology: isotherms (lines of equal temperature, Plate 24); isobars (lines of equal pressure, Plate 25); isohyets (lines of equal precipitation, Plate 27). In these examples the data are continuous in their distribution and change only in amount or degree. Some authorities therefore distinguish *isopleths*, or lines of equal value drawn through data that are discontinuous, such as the distribution of people on the face of the earth. Very often the interval between isarithms or isopleths is given a color or pattern to focus attention not on the line of equal value but on the

[1]Examples are: C. K. Wentworth, "A Simplified Method of Determining the Average Slope of Land Surfaces," *American Journal of Science*, Series 5, Vol. 20 (1930), pp. 184–194. E. Raisz and J. Henry, "An Average Slope Map of Southern New England," *Geographical Review*, Vol. 27 (1937), pp. 467–472. Guy-Harold Smith, "The Relative Relief of Ohio," *Geographical Review*, Vol. 25 (1935), pp. 272–284.

value category comprehended between two such lines. This principle is used in the snowfall map of Canada (Fig. 141), the average rainfall map of the world (Plate 7), and the population maps of the world (Plates 1 through 6).

33. Quantitative data may also be represented by dots placed on the map. These dots may have a uniform value as on the maps of corn production in the United States (Fig. 120), or their value may differ with the size of the dot as in the map of distribution of population in Pennsylvania (Fig. 90). In either case the visual impression of distribution may be excellent if the relationships between scale, size, or sizes of dots and values of dots are carefully considered. However, the difficulty of counting many dots, and the impossibility of counting merging dots limits the quantitative use of this symbol system. To obviate this objection, various schemes have been proposed such as arrangement of dots in countable patterns like squares or rectangles; use of open or shaded large circles through which the individual dots of congested areas may be recognized; employment of "spherical dots," in which value equals the volume of the sphere rather than area of the circle or dot; and the erection of square dots or cubes into piles of blocks. The latter is a step toward a graphical system. It is possible to place any of the common figures such as pie graphs, bar graphs, and line graphs on the face of a map.

34. Non-quantitative distributions are represented by a great diversity of symbols indicating points, linear patterns, or areal patterns. Sometimes the symbol selected is purely arbitrary, and sometimes it is a pictorial effect. Consider as an example the map of the rice-land topography on the delta of the Mahanadi (Fig. 29). Drainage ditches and unpaved roads use symbols employed on many maps, although the ditch symbol also is used for a wall on some maps. Coastal bar and waste land is an arbitrary symbol easily drawn and in good contrast to the mangrove and jungle symbol, which attempts to look like the vegetation it presents. One must read more closely and accurately to appreciate that the blank areas are rice land, the avowed subject of the map. Because symbols are not always self-explanatory, a well-considered map has a legend or key defining such symbols. It is a good map-reading habit to examine the legend as well as

the scale (and contour interval and projection) before attempting the interpretation of a map.

35. Greater legibility on maps often is obtained by the use of colors. Colors may be selected with some relationship to the facts they present, as, for example, on many atlas maps presenting the world distribution of natural vegetation. The number of categories being limited, colors may be selected that suggest the vegetative associations portrayed. The Dry Lands and Grasslands may be assigned grays or yellows whose color density varies in proportion to the floral density. The forest groups may be designated by greens whose shades and densities may be related to temperature concepts. Tundra and ice caps may then be gray or white. Colors thus used are easily remembered. A false impression often is conveyed to the uninitiated by the hypsometric system used to represent altitude of land surfaces, particularly on small-scale maps. Contour lines at large and often irregular intervals separate colors which usually begin with greens at low altitudes and progress through yellows and browns to reds at high altitudes. Because of the infrequency of the contour lines and the wide extent of the color areas, the unfortunate and erroneous impression may be given that elevation changes abruptly at the contact of two colors, and that little change takes place within a given color area.

Legibility of maps is more than a matter of color or of symbol selection. It is related to the function of the map. Topographic maps portraying many of the tangible features of a landscape and some related intangible data require approximately equal emphasis and clarity among cultural symbols, so that all may be distinguishable, and sufficient emphasis on physical symbols (often obtained through color) so that they form a readily intelligible pattern upon which the cultural symbols are distributed. Maps of smaller scale covering larger areas usually place particular emphasis on a limited number of distributions. For example, note the emphasis given to Indian trails in Michigan in Fig. 85 and to the road from Peshawar to Bokhara in Fig. 191. Lack of a striking symbol for the cropland of Alaska in Fig. 153 makes the cropland difficult to locate among the mountains and taiga.

V. Map Sources and Collections

36. **Atlases.** Collections of maps brought together in bound or loose-leaf form are known as atlases. Because of their great utility and handiness compared to individual sheet maps, atlases form a basic reference source comparable to dictionaries and encyclopedias. The subject area of an atlas may be as general as the world, or as detailed as a county or other minor political division. In the United States most atlases are produced commercially, but some countries, such as France, Finland, Poland, Czechoslovakia, the U.S.S.R., and Canada, have provided extremely valuable and significant national atlases.

37. **Sheet Maps.** Unbound sheet maps exist for such a variety of areas and subjects, and in such tremendous quantities, that reference collections are very limited in comparison with the distribution of atlases. In the United States, local and state government offices and libraries often are well supplied with sheet maps of their particular areas. For the nation as a whole and for foreign coverage the major sources available to the student or map user are the Federal Government and the major geographical societies. Inquiries concerning domestic mapping may be directed to Map Information Office, U. S. Geological Survey, Washington 25, D. C. This office has knowledge not only of the topographic quadrangles and other mapping work of the U.S.G.S. but also of the work of the Coast and Geodetic Survey, the U. S. Department of Agriculture, and all other mapping sections of the Federal Government. Foreign map collections of real significance exist in Washington at the Library of Congress, Army Map Service (Department of the Army), Hydrographic Office (Navy Department), and Department of State. The most important non-governmental collection is in New York City at the American Geographical Society.

The list of publishers of sheet maps is very extended. However, a limited number of publishers should be known to every map user. For the United States, the topographic quadrangles of the U.S.G.S. (supplementary work by Mississippi River Commission; U.S.C.&G.S., Tennessee Valley Authority; and others) are basic. The largest scale map covering all the United States is supplied by the Coast and Geodetic

Survey's 1:500,000 air map. In the field of foreign and world mapping, the International Map of the World occupies an important position. This map is intended to cover the entire world at 1:1,000,000 as a co-operative effort among many nations, following map specifications agreed upon in 1909 and subsequently. Although far from complete, great progress has been made, particularly during World War II. The American Geographical Society has completely mapped the Americas south of the United States. European coverage has been completed by various national groups, and reissued by the British government, which also has prepared large parts of Asia and of Africa. The British group working on this and many others maps in Europe, Africa, and Asia is the Geographical Section of the General Staff (GS,GS). The American counterpart, which worked co-operatively with GS,GS during World War II to fill in the gaps in world maps at various scales, is the Army Map Service (AMS). Through the latter many universities and public libraries in the United States are participants in a map depository program which features the placement of AMS copies of foreign topographic maps in major population centers throughout the country.

Most topographic maps are of such detail that they must be issued in many individual sheets which form parts of the whole map. These sheets make up a set (or series) of maps. A map set commonly has the same characteristics throughout its sheets, which differ from each other primarily in position. The usual method of keeping records of these sheets is to plot them in miniature on a small-scale index map. All the maps mentioned in the paragraph above are grouped into sets.

Sheet maps which do not comprise sets must be regarded as individual items. Their cataloguing and filing raise problems comparable, but not entirely similar, to problems encountered with books and documents. The primary differences between the latter and maps are that area is the map subject of importance, and that a map is physically a thin, and often large, sheet of paper. A number of library systems for maps have been devised, but no general recognition of the merits of a particular one over all others has been forthcoming. However, the most useful systems all depend upon division of the world into arbitrary areas (usually political units). Small-scale maps of large areas are then catalogued with the major divisions of the world, and large-scale maps

of small areas with the subdivisions. Maps that present unusual combinations of area are placed in one arbitrary division and cross-referenced as necessary. In large collections, the designation of area is supplemented with a definition of subject matter of the map. With these principles in mind, it will be found that the library system of any of the major collections may be readily used.

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B · THE ATMOSPHERE

I. *Some Fundamental Meteorological Principles*[1]

1. **Composition of the Atmosphere.** The atmosphere is a mixture of gases. About 78 per cent is nitrogen and about 21 per cent is oxygen; but of the remaining 1 per cent the small proportion of water vapor and carbon dioxide is of the greatest importance in determining the character of the earth's climates. Water vapor is confined almost wholly to the lower layers of the atmosphere, 90 per cent of it lying below twenty-one thousand feet. Its average mass the world over is such that, if it were condensed, it would be the equivalent of a layer of water about one inch deep over the entire surface of the earth.

2. **Insolation.** For all practical purposes the sun is the only source of the heat which maintains the temperature of the earth's surface and the atmosphere. The solar radiation received at the surface of the earth depends upon four things: (1) the solar output of radiation, which fluctuates slightly in cycles of more or less regular recurrence; (2) the distance of the earth from the sun, which varies seasonally during the passage of the earth around the sun; (3) the inclination of the sun's rays to the plane of the horizon, which varies seasonally owing to the inclination of the earth's axis to the plane of its orbit and which also varies with latitude and local exposure; and (4) the transmission and

Latitude	0	10	20	30	40	50	60	70	80	90
Summer half-year	160.5	169	173.5	173	169	160.5	149	139	134	133
Winter half-year	160.5	147	129.5	109	84	58.5	33	13	4	0
Annual	321.0	316	303.0	282	253	219.0	182	152	138	133

[1] These greatly condensed statements can offer to the student little more than an outline. The demands of time and space in this general survey do not permit a more penetrating treatment of the fundamental elements of geography; the student who plans to go on professionally must go much more deeply into the basic sciences of meteorology, climatology, geology, and geomorphology.

absorption of the atmosphere. The preceding table (reference 10, p. 528) gives the total amounts of insolation (in kilogram-calories per square centimeter of level surface) at the top of the atmosphere. From these figures we see that in a year only about 40 per cent as much insolation is received above the poles as above the equator, and also that the rate of insolation falls off most rapidly between latitudes 50° and 60°.

3. **Heating of the Earth's Surface.** The effect of the distribution of insolation over the earth is to produce, in general, the greatest amount of heating near the equator and the least amount at the poles. This simple latitudinal arrangement, however, is complicated by the *differential heating of land and water.* Water heats more slowly than land and retains its heat longer under similar atmospheric conditions. The relatively slow heating of water is the result chiefly of three facts: (1) the specific heat of land is lower than that of water; (2) water is translucent, so that a given amount of insolation which is concentrated on the surface of the land penetrates through a considerable depth of water; and (3) water is mobile, and so can distribute the heat which it absorbs. Radiation from a water body being less rapid than from the land, the former retains for a longer period the heat which it receives.

4. **Heating the Air.** About 37 per cent of the solar radiation which reaches the top of the atmosphere is returned again to space by reflection, chiefly from upper cloud surfaces, but in part also from the earth's surface, especially from ice and snow. Of the 63 per cent not immediately returned to space, only about 10 per cent is absorbed by the atmosphere, and the remainder makes its way directly, or as diffuse sky-light, to the earth's surface.

The atmosphere is warmed chiefly by *conduction*, or contact with the earth, and by *radiation* from the earth. Owing primarily to the water vapor and, to a lesser extent, to the ozone and carbon dioxide, the air is able to absorb about 90 per cent of the long-wave terrestrial radiation, whereas it can absorb only about 10 per cent of the solar radiation. Since radiation absorbed in an air stratum is again radiated equally upward and downward, 45 per cent of the outgoing terrestrial radiation is returned again to the earth, and an equal amount finds its way out to space.

5. **Cooling of the Earth.** Eventually as much heat is radiated from the earth as is received from the sun, for if this were not true the earth's average temperature would not remain approximately constant. The effect of the atmosphere is to let through the incoming solar radiation and to intercept the outgoing terrestrial radiation, so that the surface temperature of the earth is somewhat higher than it would be without the protection of its gaseous envelope. The effect of this absorption of earth radiation is greater as the amount of water vapor increases. The cooling of the earth's surface by radiation is therefore most rapid at high altitudes and in dry regions where the amount of water vapor is at a minimum.

6. **Vertical Arrangement of Temperature.** Because the atmosphere is heated chiefly from the surface of the earth, the temperature generally decreases with increasing altitude. Up to an elevation of from six to nine miles this decrease is about 1° F. for each three hundred and thirty feet of increased altitude. This is the average *vertical temperature gradient* in the free air. Above six to nine miles (higher over the equator and lower near the poles) the temperature remains fairly constant with increasing elevation. This upper atmosphere is known as the *stratosphere* (illustrated by Fig. 170, p. 392). The lower zone, in which the temperature decreases with increasing altitude and in which vertical air movements are common, is known as the *troposphere.*

7. **Adiabatic Cooling and Warming of Air.** A mass of rising air is cooled adiabatically; that is, without the removal of any heat from the mass of air involved. With increase of elevation the pressure decreases (see section 9, p. 508) and the air expands. As air expands, it cools; in a mass of rising dry air this rate of cooling is about 1.6° F. for every three hundred feet. This is the dry *adiabatic rate.* When an air mass descends, this process is reversed, the air being warmed adiabatically at the same rate.

When the cooling of air results in the condensation of water (sect. 14), the dry adiabatic rate no longer prevails. Because of the liberation of latent heat in the process of condensation, the rate of temperature decrease becomes less, and the departure of this *retarded adiabatic rate* from the dry rate is greater as the rate of condensation is greater.

8. **Vertical Air Movements.** When the temperature of a mass of air is higher than that of surrounding air, the colder air settles and forces the warmer air to rise. This action is due to the fact that colder air has a greater density than warmer air. As long as the rising air mass is relatively warmer than the surrounding air at the same level, it will continue to rise. The relationship between the vertical temperature gradient in the surrounding air and the adiabatic rate in the rising air determines, therefore, whether a vertical movement shall continue or quickly cease. For if the rising air is cooled so rapidly that it becomes cooler than the surrounding air, it must settle back. If, on the other hand, the rising air is cooled more slowly, so that the ascending air remains warmer than the surrounding air, the rise is continued. Anything which increases the vertical temperature gradient or decreases the adiabatic rate tends to increase vertical air movements. For instance, if moisture is condensing in the rising air mass, the rate of cooling is retarded (sect. 7); therefore, air in which moisture is condensing tends to be more buoyant than air in which no condensation is taking place. Buoyancy is also increased if a cold layer of air overriding a warmer surface layer increases the vertical temperature gradient.

In general, then, vertical air movements are common in warm, moist air, and if clouds are present they take the *cumulus* (cauliflower-shaped) form. Cold air, on the other hand, is sluggish and does not rise easily; clouds in such air are commonly *stratus* (sheetlike).

9. **Pressure.** Atmospheric pressure is the result only of the weight of the overlying column of air. It is commonly measured in terms of the length of a column of mercury which will balance this weight. Normal pressure at sea level is about 30 inches of mercury (exactly 29.94 in.). With increasing altitude the pressure decreases: at 5000 feet it is about 25 inches; at 10,500 feet, about 20 inches; at 16,000 feet, about 16 inches.

The pressure is not uniform over the earth's surface, however, even at sea level. In general an area which becomes relatively warm compared with a neighboring area becomes also an area of low pressure. This can be explained by a consideration of two neighboring masses of air, one of which is heated and the other cooled. The column of air which is heated expands, while the cooled-air column contracts. This

produces a movement at a high level away from the column of heated air and toward the column of cooled air, and as a result the pressure of the one is decreased and of the other is increased.

10. **Convection.** The result of the increase of pressure in one air mass and of the decrease in the other (sect. 9) is a movement of air along the surface of the earth from the cooler area, with its higher pressure, to the warmer area, with its lower pressure. In a closed system a complete circulation would become established: air moving away from the top of the warmed-air column toward the cooled column; air descending over the cooled area; air moving over the surface of the earth from the cooled area to the warmed area; and air rising over the warmed area. Such a circulation is called *convection.*

11. **Deflection Due to the Earth's Rotation.** On the surface of our planet, however, all moving bodies are deflected from their courses as a result of the earth's rotation. In this brief summary the causes of this deflection cannot be presented.[1] The fact is, however, that all moving bodies in the Northern Hemisphere are deflected to the right and that all moving bodies in the Southern Hemisphere are deflected to the left. This deflection is strongest at the poles and reaches zero along the equator.

12. **Winds and Pressures.** As a result of this deflection (sect. 11), the winds which otherwise might blow out from a center of high pressure across the isobars (lines of equal pressure) actually move parallel or nearly parallel to the isobars. In the Northern Hemisphere, with deflection to the right, the winds whirl around a high-pressure center in a clockwise direction; and in the Southern Hemisphere, with a deflection to the left, the air movement around a high is counterclockwise. The movement around a low-pressure center is just the reverse: counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. Over the oceans, where friction with the earth's surface is reduced to a minimum, the whirls are best developed and the winds are most nearly parallel to the isobars; but over the land, where friction retards the effect of the earth's rotation, the winds cross the isobars at larger angles (compare Plates 25 and 26).

[1]See reference 10, p. 176 ff.

13. **Humidity.** The amount of water vapor which can be mixed with the air depends on the temperature. At higher temperatures more water vapor can be present, but at lower temperatures much less water can exist in the air as a gas. Most of the time the actual amount of water vapor in the air is not so great as the maximum amount possible. The ratio between the water vapor actually present and the total possible amount at a given temperature is called the *relative humidity*; the ratio of the mass of water vapor to the total mass of air is called *specific humidity*. Relative humidity is measured in percentage: saturated air has a relative humidity of 100 per cent; air with half as much water vapor present as might be there has a relative humidity of 50 per cent.

14. **Condensation of Moisture.** In a mass of rising air the temperature is lowered at the adiabatic rate; and as the temperature decreases, the relative humidity, but not the specific humidity, increases. Eventually a level is reached where the relative humidity is 100 per cent. As cooling continues, the water vapor is now ready to condense into liquid form. Condensation must take place around some nucleus. As a matter of fact, in the earth's atmosphere there is no lack of minute particles, so that condensation can take place at once when the air reaches the saturation point. Condensation and the formation of clouds in nature are produced only by the cooling of moist air.

15. **Evaporation.** The evaporation of water takes place when the relative humidity of the air into which the water is evaporating is less than 100 per cent. It increases in rapidity as the relative humidity becomes lower. Water vapor can therefore be picked up rapidly by masses of descending air, since in them the temperature is constantly rising and the relative humidity falling (although, if evaporation is going on, the specific humidity is increasing). Evaporation is more rapid from warm-water surfaces than from cold-water surfaces, it is more rapid over fresh water than over salt water, and it is more rapid in windy places than in places where the air is still.

16. **Precipitation.** Precipitation includes three forms: rain, snow, and hail. Rain falls when the drops of condensed moisture become large

enough to fall through the ascending air currents. When the drops of water blown upward in the air currents reach temperatures below the freezing point, hail is formed. When the condensation takes place below the freezing point, snow crystals are formed.

The causes of rain are the same as the causes of condensation (sect. 14), although condensation may, of course, proceed only far enough to form clouds from which no precipitation takes place. In nature rain is caused almost exclusively by the cooling of moist air. Furthermore, the cooling of air is most effectively, but not exclusively, accomplished by upward movement (sect. 7). Air may be caused to rise by the convergence of air masses in motion, especially by the rapid convergence upon a center of low pressure; or it may be forced to rise as it moves onto the shore of a continent or over a range of mountains. Unless the air is warm and moist, however, rain will not be produced under either of these conditions; for the condition which would produce a rapid rise in buoyant air would cause only a sluggish rise, if any, in cold, dry air (sect. 8).

Conversely, the lack of rain in a given area is the result either of the prevalence of descending and warming air masses or of remoteness from the sources of moisture, or both.

II. The Physical Bases of Climatic Differences on the Earth

17. The Controls of Climate. The controls of climate may be grouped under seven headings: latitude, land and water, pressures and winds, cyclonic storms, ocean currents, mountain barriers, and a group of other minor controls.

18. Latitude. Because of the decrease of insolation with increase of latitude (sect. 2), there is a general decrease of air temperature toward the poles. However, this arrangement of temperature is much modified by other controls, not only seasonally but also in the average annual condition. Even the annual isotherms (lines of equal temperature) do not cross the continents parallel to the lines of latitude (Fig. 53).

19. **Distribution of Land and Water.** The differential heating of land and water is of chief importance in modifying the effect of latitude as a control of climate (sect. 3). An important distinction is recognized between *marine* and *continental* climates. Marine climates are characterized by smaller annual ranges of temperature, retarded maximum and minimum of temperature (that is, the maximum occurs in August or later in the Northern Hemisphere instead of in July), greater cloudiness, and a tendency toward fall or winter maximum of rainfall. Continental climates, on the other hand, have relatively large ranges of temperature (in other words, hotter summers and colder winters at the same latitude), the maxima and minima of temperature are not retarded (that is, they come in July and January, respectively, in the Northern Hemisphere), there is less cloudiness (especially in winter), and the rainfall shows a tendency toward a summer or late-spring maximum.

20. **Areas of High and Low Pressure** (Plate 25). Areas of high or low pressure develop over various portions of the earth's surface and remain there permanently or change with the passage of the seasons. Permanent areas of high pressure develop over those portions of the earth which remain throughout the year relatively much colder than neighboring areas in the same latitude. Such areas are located over the eastern sides of the oceans at about latitude 30° north and south and also over the icecaps of the polar regions (Greenland and Antarctica). The pressures over the continental regions of the middle latitudes change seasonally: equatorward of 40° during the summer months the lands become much hotter than the neighboring oceans and build up low-pressure centers; but during the winters these lows are dissipated, and where broad land masses extend far into the higher middle latitudes (poleward of 50°, as in North America and Eurasia) they become much colder than neighboring water bodies of the same latitude and develop winter high pressures.

21. **General Circulation of Air** (Plate 26). There are three elements in the general circulation of air on the earth: (1) the *oceanic whirls*; (2) the *monsoons*; and (3) the *polar outbursts.*

The air moves around the permanent oceanic highs in great whirls. Because of the location of these highs about latitude 30° over the oceans, the air in the low latitudes moves generally from the east, and the air in the middle latitudes moves generally from the west. Over the bordering land masses the air over the east coasts in lower middle latitudes is moving poleward, while the air on the western sides is moving equatorward. Traditionally the easterly winds of the low latitudes are known as *trade winds*, and the westerly winds of the middle latitudes are known as *westerlies*. These winds are best developed over the oceans. The zone of high pressure about latitude 30° is known as the *horse latitudes*. The belt of calms along the equator where the two oceanic whirls converge is known as the *doldrum belt*.

The coasts of large land masses in lower middle latitudes and higher low latitudes which face toward the equator develop great seasonal differences between the temperatures and pressures over the land and over the water (sect. 3). Along these coasts, therefore, the oceanic whirls are interrupted by monsoons—winds which blow for six months in one direction and for six months in the opposite direction. These winds are onshore in summer and offshore in winter, deflected to the right or left according to the hemisphere. The greatest monsoon area of the world involves the whole south-facing coast of Asia and the north-facing coast of Australia. A monsoon tendency, subject to occasional interruptions, occurs also along the east coasts of continents in lower middle latitudes, where the oceanic whirl is made stronger in summer and is replaced by offshore winds in winter.

The polar outbursts are generated in areas of cold air accumulation. These are chiefly the permanently ice-covered lands—Greenland and Antarctica—and to a lesser extent the polar ocean, and the snow-covered surfaces of the northern continents in winter. Cold air accumulates under conditions of clear skies and an absence of surface winds. When conditions permit, the cold air is heavy enough to move away from the center of accumulation. It moves in all directions from the center, but chiefly toward the nearest area of low pressure, that is, the nearest warm area. Frequent outbursts therefore take place southeastward from Greenland to the North Atlantic Drift (Plate 23). Over the land these outbursts are known as *Polar Continental* air masses. As

each puff of cold air moves southward over the northern continents it is warmed in its lower layers and is gradually pushed eastward in the stream of the westerlies. The cold air masses come farther and farther south as the Northern Hemisphere winter proceeds because they can move over previously snow-covered surfaces and so are to a less extent warmed in their lower layers. The cold waves which reach farthest toward the equator come in late winter and move over largely snow-covered lands. In summer, the cold air masses are quickly warmed and cannot push so far into the stream of the oceanic whirls. Cold air masses, being heavy and lying close to the earth, are to a much greater extent guided by terrain features than are the warm air masses of tropical origin. Also the deflective force of the earth's rotation has less effect on these moving masses of heavy air than on lighter tropical air, and consequently they move nearly at right angles to the isobars. For this reason the high pressures are speedily reduced, and the outbursts are pulsatory rather than continuous.

The actual wind in any one locality may be the result of the interaction between all three of these major systems. Cold air masses, perhaps much modified in their lower layers, penetrate far toward the equator. They push all the way across North America to the Caribbean; and one exceptionally strong polar outburst from Antarctica in 1942 brought temperatures in the 40's to the Amazon across the central lowlands of South America. It is important to note that only the cold air masses while they are still cold and heavy can move for long distances in nearly straight lines. All other air masses must move in curved lines under the action of the earth's deflective force, except within about 10° of the equator. So it is that easterly winds can cross northern South America and bring rain to the eastern slopes of the Andes. In the middle latitudes air masses moving onto the land from warm water areas cannot carry moisture to the continental interiors, which consequently remain dry.

22. **Cyclonic Storms.** It is chiefly the interaction between the air masses which form a part of the oceanic whirls and the air masses originating as polar outbursts which produces cyclonic storms. The term "cyclone" is applied to any whirling storm. In the tropics, on

the eastern sides of the continents poleward of 10°, violent whirling storms known as *hurricanes* or *typhoons* sometimes develop and move along in the general stream of the oceanic whirl. Very violent local whirls of air in mid-latitude plains sometimes develop out of thunderstorms. These are *tornadoes.* These are all special kinds of cyclones—and in the popular vocabulary the word "cyclone" usually applies to such very violent storms. But meteorologists use the term "cyclone" also to apply to the much less violent whirling storms which develop normally and frequently along the fronts of advancing cold air masses.

As the cold air masses originating as polar outbursts are projected into the stream of relatively warm light air of the oceanic whirls, they become separated from the source region and proceed as homogeneous bodies of air shaped much like drops of water running on an inclined surface: they are steep in front, rounded on top, and trail out behind. The lighter winds of the westerlies ride up over the backs of these cold air masses, the rising air forming clouds and perhaps bringing rain in the process. But the warm light air forms eddies around the front of the cold air mass, eddies which circulate counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. As the eddies form on the cold front, the cold air mass moves forward, pushing the eddy itself aloft. The result is strong, shifting winds, much cloudiness, and heavy rains. Along the immediate cold front thunderstorms develop in summer when the air of the oceanic whirl has a high temperature and carries much water vapor. In winter the advance of the cold air mass is marked by the familiar signs of an approaching storm—cirrus clouds, then stratus clouds forming a gray pall over the sky, then dark nimbus rain or snow clouds. The blizzards of the plains of North America are carried along by the front of the cold air through which snow is falling from aloft. Then the clouds are swept away and the weather becomes clear and cold. The alternation of warm, humid air of equatorial origin and clear, cold air of polar origin provides the rapid and extreme weather contrasts which are so characteristic of the middle-latitude climates. The accompanying figure (Fig. 224) shows the sequence of conditions during the advance of a cold air mass across North America. Since these cyclonic storms produce large-scale up-

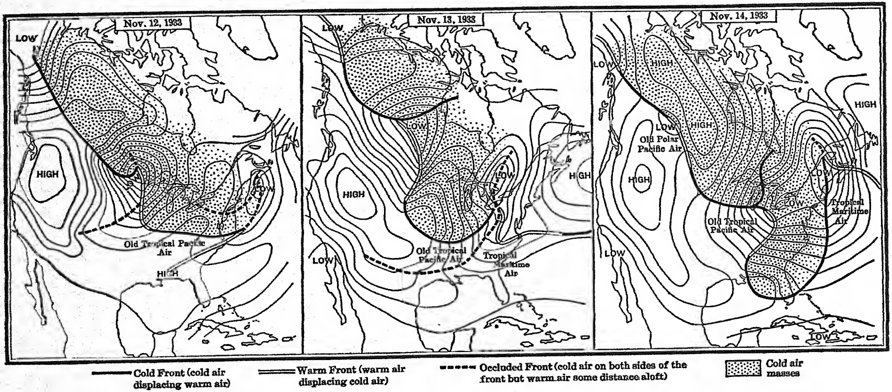

FIG. 224. *Air mass movements across North America on three successive days.* (Stippled areas are covered by air of polar-continental origin. These maps illustrate the southeastward advance of a fresh mass of polar air from its place of origin over northern Canada. Temperatures dropped from 20° to 30° in the midwestern states as the old tropical air was displaced. A second surge of cold polar air followed the first one. Rain or snow fell along the fronts where warm moist air was forced to rise and cool. The polar air masses, however, brought clear, cold weather. After H. C. Willett)

drafts of air, they are major causes of heavy rainfall, especially where the lighter air which they meet is already carrying large quantities of moisture.

23. **Ocean Currents** (Plate 23). The circulation of water in the oceans (see Appendix D, section 3) brings warm water into higher latitudes and cold water into the lower latitudes, and is therefore of great importance in producing the temperature differences which, in turn, maintain the system of pressure and winds. The arrangement of the warm and cold ocean water with reference to latitude and the continental coasts is a major factor, also, in determining the supply of moisture.

Where warm water closely approaches very cold lands there is a frequent and often violent movement of cyclonic storms. The world's stormiest ocean is in the higher middle latitudes of the Southern Hemisphere surrounding the ice-covered Antarctic continent. Very stormy, also, are the warm waters south and southeast of Greenland, and those which approach the coldest part of Siberia in the North Pacific. These are all regions of maximum cyclonic activity and so of frequent and violent weather changes.

Since cold water yields little moisture to the air (sect. 15) and since the cooled air is sluggish and heavy, the coasts which have cold water to windward of them are commonly dry. Since cold water occurs on the west coasts of the continents from about 15° to 35°, this is also a region of low rainfall—especially the center of the belt between 20° and 30°, where the land is arid. Warm ocean water, on the other hand, is the one major source of moisture in the air, and lands which have warm water to windward are usually wet.

These relationships can be seen clearly by comparing the maps of rainfall, winds, and ocean currents (Plates 23, 26, and 27).[1]

24. **Mountains.** Mountains produce important local differences of climate. Updrafts of air through mountain valleys result in bringing more rain to mountainous areas than to neighboring lowlands. However, the effect of mountains in producing rain depends to a large

[1]See reference 13, pp. 599 ff.

degree on the character of the air which blows against them. Cold air can rise only sluggishly, if at all, and may produce only a low stratus cloud, as along the Peruvian coast. The heaviest rains in the world, however, are received on mountain slopes which lie in the path of warm, buoyant, moisture-laden air (sect. 8).

East-west mountain ranges act as temperature divides as well as rain-producers. If the movement of north or south winds is prohibited, the lowlands on the poleward side of a mountain range are made colder than they would otherwise be, and the lowlands on the equatorward side are made warmer.

25. **Other Lesser Controls of Climate.** Local climates are affected by other lesser controls. Forests moderate the temperature somewhat. The effect of forests on rainfall has been greatly exaggerated: rainfall is produced by forces which can be affected by the vegetation to only a very minor degree. Evaporation is greater over a forest than over bare ground, so that a forest cover permits the moisture from the ocean to penetrate farther inland than would be the case if no forests were present. But agricultural land is probably fully as effective as a forest in providing moisture for evaporation.

Among the many other minor controls affecting temperature and humidity are soils, and even the works of man, such as cities.

III. The Köppen Classification of Climates

26. The Köppen classification of climates is a quantitative system based on monthly and annual means of temperature and rainfall. Unlike many other climatic classifications, the lines which are used to limit the climatic types are given exact definitions and so are subject to checking and revision on the basis of new data. The boundaries, being isarithms (that is, connecting points of equal value), reveal the arrangement of the climatic elements much as contours reveal the shape of a hillside. The direction of greatest climatic difference is always at right angles to the boundary lines. The values which are used in the definitions of these boundaries are based on temperature, on precipitation,

or on combinations of these. This is not only because temperature and rainfall are among the most important climatic elements but also because these data are the only ones which are available for a large number of stations throughout the world. The Köppen system has become an international standard, and therefore it is presented in this book without modification.

27. **The History of the Classification.** Dr. Wladimir Köppen spent more than fifty years of his lifetime in the development of the system of classification which bears his name. His first attempt at a world classification included only temperature distinctions.[1] In 1900 temperature and moisture were both considered.[2] Eighteen years later a revised statement of the climatic classification was published, this time in essentially its present form.[3] With minor variations of definition, the system formed the basis of a book on world climatology, published in 1923.[4] Important revisions were introduced, however, on a wall map published by Köppen and Geiger in 1928. On this map certain changes in definition were made which were later discarded. The wide use of the wall map and the reproduction of its lines and definitions elsewhere have led to considerable confusion. In 1931 a second edition of Köppen's book was published, with still further revisions.[5] This last publication remains the latest pronouncement, and the definitions contained in it are being used in the preparation of a handbook of climatology.[6]

28. **Main Outlines of the System.** Köppen recognizes five major divisions of the world's climates. These divisions were intended to corre-

[1]W. Köppen, "Die Wärmezonen der Erde, nach der Dauer der heissen, gemässigten und kalten Zeit, und nach der Wirkung der Wärme auf die organische Welt betrachtet," *Meteorologische Zeitschrift*, Vol. 1 (1884), pp. 215–226.

[2]Ibid. "Versuch einer Klassifikation der Klimate, vorzugsweise nach ihren Beziehungen zur Pflanzenwelt," *Geographische Zeitschrift*, Vol. 6 (1900), pp. 593–611.

[3]Ibid. "Klassifikation der Klimate nach Temperatur, Niederschlag, und Jahreslauf," *Petermann's Mitteilungen*, Vol. 64 (1918), pp. 193–203, 243–248.

[4]Ibid. *Die Klimate der Erde*, Berlin, 1923.

[5]Ibid. *Grundriss der Klimakunde*, Berlin, 1931.

[6]W. Köppen and R. Geiger, *Handbuch der Klimatologie* (in five volumes by various authors, still incomplete because of the disruption of German science by World War II).

spond with A. de Candolle's five principal vegetation groups.[1] The five climatic divisions, identified by capital letters, are: *A*, rainy climates with no winters (no cool or cold season); *B*, dry climates; *C*, rainy climates with mild winters; *D*, rainy climates with severe winters; and *E*, polar climates with no warm season.

These various major categories are then subdivided. The *B*, or dry climates, are separated into semiarid, *BS* (*S* from the word *steppe*, or dry grassland), and arid, *BW* (*W* from the German *Wüste*, meaning "desert"). The polar deserts, or *E* climates, are subdivided into the marginal or tundra type, *ET*, and the climates of continuous frost, *EF*. The rainy climates, *A*, *C*, and *D*, are subdivided on the basis of the distribution of rainfall through the year. Those with no marked dry seasons are identified by the small letter *f* (from the German *feucht*, meaning "moist"), those with winter dry seasons are indicated by the small letter *w*, and those with summer dry seasons are indicated by the small letter *s*.[2]

Still further subdivision is made on the bases of other significant features of temperature and rainfall (sect. 30).

29. Procedure in Classifying a Climate. Since all these various letters have quantitative definitions, it is possible to determine from the statistics of temperature and rainfall the proper symbols to describe a climate.

[1]A. de Candolle, "Constitution dans le règne végétal des groupes physiologiques applicables à la géographie ancienne et moderne," *Archives des sciences physiques et naturelles*, Geneva, May, 1874.

De Candolle recognized as his five major plant groups: (1) megatherms, plants needing continuously high temperature and abundant moisture; (2) xerophytes, plants which tolerate dryness and need at least a short hot season; (3) mesotherms, plants needing a moderate amount of heat and a moderate supply of moisture; (4) microtherms, plants needing less heat, less moisture, and tolerant of shorter summers and colder winters; (5) hekistotherms, plants of the polar zone beyond the limits of the forest. It is now recognized that this classification of plants is quite inadequate. Any classification of climates, however, would recognize Köppen's basic categories, so that this historical relation to De Candolle is irrelevant.

[2]Note that there is an important distinction between capital and small letters. Capital *W* and capital *S* are used only with the *B* climates; small *w* and small *s* are used throughout the system, in every case to indicate the presence of a dry season. Similarly, *F* is used only with *E* climates and must not be confused with *f*. It is important, in writing the climatic symbols, to distinguish carefully between capital and small letters.

Climatic data for numerous stations are given in Appendix E. The following procedure should be used in the classification of each station:

1. Is the station *E*? If so, is it *ET* or *EF*? If not—
2. Is the station *B*? If so, is it *BS* or *BW*? If one of these, what small letters must also be used? If not—
3. Is it *A*, *C*, or *D*? If *A*, is it *f*, *m*, or *w*? If one of these, what other small letters must also be used? If *C*, is it *f*, *s*, or *w*, and is it *a*, *b*, or *c*? What other small letters must also be used? If *D*, is it *f*, *s*, or *w*, and is it *a*, *b*, *c*, or *d*? What other small letters must also be used?

30. **Definitions of the Symbols.** The following definitions are arranged under the five major types and in the order *E*, *B*, *A*, *C*, and *D*. The figures are given in Fahrenheit degrees and inches, with the equivalents in centigrade and centimeters given in parentheses.[1]

E CLIMATES

E: warmest month below 50° (10°). *ET:* warmest month below 50° (10°) and above 32° (0°). *EF:* warmest month below 32° (0°).

B CLIMATES

Several formulae are used to identify the dry climates. This is necessary because the effectiveness of the rainfall in providing moisture in the ground for plants varies with the rate of evaporation, which, in turn, varies with the temperature and with the other elements previously listed (sect. 15). The formulae for the identification of the semiarid and arid climates must therefore take into account the total annual rainfall and the temperature, and they must also show that if the rain comes chiefly in the hot season its effectiveness is decreased, and that if it comes chiefly in the cold season its effectiveness is increased.

The phrase "chiefly in summer" is interpreted as meaning that at least 70 per cent of the total annual rainfall comes in the summer six months (April to September, inclusive, in the Northern Hemisphere). "Chiefly in winter" means that at least 70 per cent comes in the winter six months (October to March, inclusive, in the Northern Hemisphere). If less than 70 per cent is concentrated in either six-month period, then the rainfall is said to be evenly distributed.[2]

[1]Definitions from reference 7, pp. 127–136.

[2]Köppen's text is not definite concerning the exact meaning of "chiefly in summer" etc. Many writers use the same definition of summer rain as is used for the identification of *w* with *C* and *D* climates (ten times as much rain in the rainiest summer month as in the driest winter month). The most adequate definition hitherto suggested has been worked out by Russell, who recognizes nine rainfall regimes instead of only three (R. J. Russell, *Dry Climates of the United States, I, Climatic Map*, University of California Publications in Geography, Vol. 5 (1931), pp. 16–22).

There are two sets of formulae. One set gives us the humid limits of the dry climates, *BS/H*; the other set gives us the limits between arid and semiarid, *BW/BS*. There are three formulae in each set—one for evenly distributed rain, one for summer rain, and one for winter rain.

In these formulae r is the amount of rain which marks the humid boundary of the *B* climates, the amount of rain less than which is considered deficient; r' is the amount of rain which marks the limit between arid and semiarid, less than which is considered arid; t is the average annual temperature. The formulae are based on an empirical relationship between the temperature in degrees centigrade and the rainfall as measured in centimeters. They can therefore be used only with centigrade degrees and centimeters.

	BS/H	*BW/BS*
Rainfall evenly distributed	$r = 2(t + 7)$	$r' = t + 7$
Rainfall chiefly in summer	$r = 2(t + 14)$	$r' = t + 14$
Rainfall chiefly in winter	$r = 2\,t$	$r' = t$

These formulae were used in the preparation of the numerical tables on pages 524 and 525, which are given in degrees Fahrenheit and inches. Table I gives the *BS/H* boundary; Table II gives the *BW/BS* boundary.[1]

The following small letters are also used with the *BW* and *BS* climates:

h: average annual temperature over 64.4° (18°).
k: average annual temperature under 64.4° (18°).
k': temperature of the warmest month under 64.4° (18°).
s: indicates that at least 70 per cent of the rain falls in the winter six months.
w: indicates that at least 70 per cent of the rain falls in the summer six months.

(The absence of *s* or *w* indicates that the rainfall is evenly distributed.)

Letter Combinations in the B Climates

BSh, BShs, BShw; BSk, BSks, BSkw; BSk', BSk'w
BWh, BWhs, BWhw; BWk, BWks, BWkw; BWk', BWk'w

(The small letter *n* is sometimes added to these to indicate the presence of frequent fogs. This letter, however, is not given exact definition and cannot be identified from the climatic data given in this book.)

A CLIMATES

A: temperature of the coldest month above 64.4° (18°).
f: rainfall of the driest month is at least 2.4 in. (6 cm.).

[1]These tables were prepared by Dr. Henry M. Kendall.

m: short dry season exists, but is compensated by heavy rains during the rest of the year (see *w*).

w: dry season exists which is not compensated by rains during the rest of the year. The dry season comes during the low-sun period of the hemisphere.

w′: used if the rainfall maximum comes in autumn of the hemisphere.

w″: used if there are two distinct maxima of rainfall, separated by two dry seasons.

s: used when the dry season comes during the high-sun period.

The distinction between *m* and *w* (*w′*, *w″*, and *s*) depends upon the amount of rain in the driest month and the total annual rainfall. As the total annual rainfall increases, smaller and smaller amounts of rain in the driest month can be compensated. If the total annual rainfall is 100 inches (exactly 98.5 in.), one month can be completely dry and still merit the symbol *m*; or if the total annual rainfall is 200 inches, two months can be entirely dry. The distinction between *m* and *w* is given in the table on page 526, in which the amount of rain in the driest month varies inversely with the total annual rainfall. If the rainfall of the driest month is less than the amount shown in the second column, the symbol *w* (*w′*, or *w″*, or *s*) is used; if the rainfall is more, but less than 2.4 (*f*), the symbol *m* is used.[1]

After *f* or *m* the letter *w*, *w′*, *w″*, or *s* is sometimes used to indicate the season of less rain.

i: range of temperature between the coldest and warmest months less than 9° (5°).

g: hottest month comes before the solstice.

Letter Combinations in the A Climates

Afi, *Afwi* (*w′*, *w″*, *s*)
Am, *Ami*, *Amwi* (*w′*, *w″*, *s*)
Aw, *Awi*, *Aw′*, *Aw″*, *As* (*i*); *Awg*, *Awgi*, etc.

C Climates

C: temperature of the coldest month below 64.4° (18°) but above 26.6° (− 3°); temperature of the warmest month over 50° (10°).

f: no dry season; difference between rainiest and driest month less than that required for *s* or *w*; or, in the case of winter rain and summer drought, driest month of summer receives more than 1.2 in. (3 cm.).

s: dry season in summer; rainiest month of winter receives at least three times as much rain as the driest month of summer, and the driest month of summer receives less than 1.2 in. (3 cm.).

[1]The table was prepared by Dr. Henry M. Kendall.

TABLE I. FOR THE DETERMINATION OF THE *BS/H* BOUNDARY

Average Annual Temperature	At Least 70 Per Cent in Winter	Even Distribution	At Least 70 Per Cent in Summer
32	.00	5.52	11.02
33	.44	5.96	11.46
34	.86	6.38	11.88
35	1.32	6.82	12.34
36	1.74	7.26	12.76
37	2.18	7.70	13.20
38	2.62	8.14	13.64
39	3.06	8.58	14.08
40	3.50	9.02	14.52
41	3.94	9.46	14.96
42	4.38	9.90	15.40
43	4.82	10.34	15.84
44	5.26	10.78	16.28
45	5.68	11.20	16.70
46	6.12	11.64	17.14
47	6.56	12.08	17.58
48	7.00	12.52	18.02
49	7.44	12.96	18.46
50	7.88	13.40	18.90
51	8.32	13.84	19.34
52	8.74	14.26	19.76
53	9.18	14.70	20.20
54	9.62	15.14	20.64
55	10.06	15.58	21.08
56	10.50	16.02	21.52
57	10.94	16.46	21.96
58	11.38	16.90	22.40
59	11.82	17.34	22.84
60	12.26	17.78	23.28
61	12.68	18.20	23.70
62	13.12	18.64	24.14
63	13.56	19.08	24.58
64	14.00	19.52	25.02
65	14.44	19.96	25.46
66	14.88	20.40	25.90
67	15.30	20.82	26.32
68	15.74	21.26	26.76
69	16.18	21.70	27.20
70	16.62	22.14	27.64
71	17.06	22.58	28.08
72	17.50	23.02	28.52
73	17.94	23.46	28.96
74	18.38	23.90	29.40
75	18.82	24.34	29.84
76	19.24	24.76	30.26
77	19.68	25.20	30.70
78	20.12	25.64	31.14
79	20.56	26.08	31.58
80	21.00	26.52	32.02
81	21.44	26.96	32.46
82	21.88	27.40	32.90
83	22.30	27.82	33.32
84	22.74	28.26	33.76
85	23.18	28.70	34.20

TABLE II. FOR THE DETERMINATION OF THE *BW/BS* BOUNDARY

AVERAGE ANNUAL TEMPERATURE	AT LEAST 70 PER CENT IN WINTER	EVEN DISTRIBUTION	AT LEAST 70 PER CENT IN SUMMER
32	.00	2.76	5.51
33	.22	2.98	5.73
34	.43	3.19	5.94
35	.66	3.42	6.17
36	.87	3.63	6.38
37	1.09	3.85	6.60
38	1.31	4.07	6.82
39	1.53	4.29	7.04
40	1.75	4.51	7.26
41	1.97	4.73	7.48
42	2.19	4.95	7.70
43	2.41	5.17	7.92
44	2.63	5.39	8.14
45	2.84	5.60	8.35
46	3.06	5.82	8.57
47	3.28	6.04	8.79
48	3.50	6.26	9.01
49	3.72	6.48	9.23
50	3.94	6.70	9.45
51	4.16	6.92	9.67
52	4.37	7.13	9.88
53	4.59	7.35	10.10
54	4.81	7.57	10.32
55	5.03	7.79	10.54
56	5.25	8.01	10.76
57	5.47	8.23	10.98
58	5.69	8.45	11.20
59	5.91	8.67	11.42
60	6.13	8.89	11.64
61	6.34	9.10	11.85
62	6.56	9.32	12.07
63	6.78	9.54	12.29
64	7.00	9.76	12.51
65	7.22	9.98	12.73
66	7.44	10.20	12.95
67	7.65	10.41	13.16
68	7.87	10.63	13.38
69	8.09	10.85	13.60
70	8.31	11.07	13.82
71	8.53	11.29	14.04
72	8.75	11.51	14.26
73	8.97	11.73	14.48
74	9.19	11.95	14.70
75	9.41	12.17	14.92
76	9.62	12.38	15.13
77	9.84	12.60	15.35
78	10.06	12.82	15.57
79	10.28	13.04	15.79
80	10.50	13.26	16.01
81	10.72	13.48	16.23
82	10.94	13.70	16.45
83	11.15	13.91	16.66
84	11.37	14.13	16.88
85	11.59	14.35	17.10

TABLE III. FOR THE DETERMINATION OF THE *Am/Aw* BOUNDARY

Yearly Rainfall in Inches	Rainfall of Driest Month in Inches	Yearly Rainfall in Inches	Rainfall of Driest Month in Inches	Yearly Rainfall in Inches	Rainfall of Driest Month in Inches
39.5	2.36	59.5	1.56	79.5	.76
40	2.34	60	1.55	80	.74
40.5	2.32	60.5	1.53	80.5	.72
41	2.30	61	1.51	81	.70
41.5	2.29	61.5	1.48	81.5	.68
42	2.26	62	1.47	82	.66
42.5	2.24	62.5	1.45	82.5	.63
43	2.22	63	1.42	83	.61
43.5	2.20	63.5	1.41	83.5	.59
44	2.18	64	1.38	84	.58
44.5	2.16	64.5	1.36	84.5	.56
45	2.14	65	1.34	85	.54
45.5	2.12	65.5	1.33	85.5	.51
46	2.10	66	1.30	86	.50
46.5	2.08	66.5	1.28	86.5	.48
47	2.07	67	1.26	87	.46
47.5	2.04	67.5	1.24	87.5	.44
48	2.02	68	1.22	88	.42
48.5	2.00	68.5	1.20	88.5	.40
49	1.98	69	1.18	89	.37
49.5	1.96	69.5	1.15	89.5	.36
50	1.94	70	1.13	90	.34
50.5	1.92	70.5	1.11	90.5	.32
51	1.90	71	1.10	91	.29
51.5	1.88	71.5	1.08	91.5	.28
52	1.86	72	1.06	92	.26
52.5	1.85	72.5	1.03	92.5	.24
53	1.82	73	1.02	93	.22
53.5	1.80	73.5	1.00	93.5	.20
54	1.78	74	.98	94	.18
54.5	1.77	74.5	.96	94.5	.16
55	1.75	75	.94	95	.14
55.5	1.73	75.5	.92	95.5	.11
56	1.70	76	.90	96	.09
56.5	1.68	76.5	.88	96.5	.07
57	1.66	77	.86	97	.06
57.5	1.64	77.5	.84	97.5	.04
58	1.63	78	.81	98	.02
58.5	1.60	78.5	.80	98.5	.00
59	1.58	79	.78		

w: dry season in winter; rainiest month of summer receives at least ten times as much rain as the driest month of winter.

a: hot summers; temperature of the warmest month over 71.6° (22°).

b: cool summers; temperature of the warmest month under 71.6° (22°), but with at least four months above 50° (10°).

c: cool, short summers; only one to three months above 50° (10°).

i: range of temperature between the coldest and warmest months less than 9° (5°).

g: hottest month comes before the summer solstice.

t': hottest month delayed until autumn.

x: maximum rainfall in spring or early summer; late summer dry.

s': maximum rainfall in autumn.

(*n* is used, as elsewhere, to indicate frequent fogs.)

Letter Combinations in the C Climates

Cfa, Cfb, Cfc; Cfbi, Cfci, Cfx
Csa, Csb; Csbt'n, Cs'
Cwa, Cwb; Cwbi, Cwg

D Climates

D: temperature of the coldest month below 26.6° (− 3°), and temperature of the warmest month above 50° (10°).

f, *s*, and *w:* defined exactly as in the *C* climates.

a, *b*, *c:* defined exactly as in the *C* climates.

d: temperature of the coldest month less than − 36.4° (− 38°).

Letter Combinations in the D Climates

Dfa, Dfb, Dfc, Dfd
Dsb
Dwa, Dwb, Dwc, Dwd

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C · THE LITHOSPHERE

I. Tectonic Forms

1. **The Earth's Crust.** The geologists recognize three major types of rocks which make up the solid crust of the earth. There are the *igneous* rocks, which have cooled and solidified from a previously molten condition. These are crystalline: coarsely crystalline where they have cooled slowly at great depths below the surface; finely crystalline, or even glassy, where they have cooled more rapidly near or at the surface. There are many kinds of igneous rocks, depending on the minerals in them. *Sedimentary* rocks make up the second major type. These are derived from the erosion of earlier rocks and were accumulated as unconsolidated deposits either in the water or on the land. The deposits range from coarse material to fine: gravels, sands, and muds. In the course of time and deep burial under later desposits, the layers of gravel, sand, or mud were gradually consolidated into rock: into conglomerate, sandstone, shale, or limestone. The third major division of rocks includes those which have been altered from either igneous or sedimentary types as a result of pressure or heat, or both. These are known as *metamorphic* rocks. Such a process rearranges the crystal structure of the igneous rocks into more compact forms. Similarly, the individual rock particles of the sedimentary strata are melted and solidified again as tightly fitted crystals. The result in either case is a rock mass which is more compact and more resistant to the processes of erosion. The coarsely crystalline igneous rocks are changed to gneiss, sandstone to quartzite, shale to slate or schist, and limestone to marble.[1]

From the point of view of the effect of these rock types on the shape of the surface of the earth the most important distinction is between those which are massive and those which are arranged in layers, or strata. Igneous rocks may be either massive or stratified; sedimentary rocks are always stratified; metamorphic rocks may be either.

[1]For a more exact discussion of rock types see any modern textbook in geomorphology, such as references 4, 14, 21, 27, and 30. The reference numbers refer to the list at the end of this appendix.

2. **Deformation of the Earth's Crust.** The rock crust of the earth has been subjected to stresses and strains throughout geologic history. Mountain ranges have been raised up only to be worn down again countless times. While certain sections of the lithosphere have remained more stable than others, there is no part which does not bear the record of some deformation. The crust of the earth is raised, lowered, broken, crumpled, or folded by these movements.

Four chief types of *tectonic* forms—that is, forms produced by forces from within the earth—are recognized. On the spheroidal surface of the planet a gentle uplift usually results in the formation of a simple *dome*. This is probably the commonest of the tectonic forms. Some mountain ranges are the result of the erosion of domes (Fig. 225); on a large scale the Laurentian Upland of northeastern North America represents a dome structure of continental proportions.

Where the forces which disturb the earth's crust are stronger, the rocks may be crumpled in the process of deformation. A *folded* structure is the result of compression which wrinkles the rock strata. Among the examples of this are strata with simple, open folds with horizontal axes. But there are many examples where the folding has been more intense: where the *anticlines*, or upfolds, have toppled over into the *synclines*, or downfolds, or where the axes of the folds have themselves been warped from the horizontal (Fig. 168). The Jura Mountains furnish a standard example of simple folding, while the Appalachians are somewhat more complex; and still more complex are the Alps, which are noted for the complicated distortions of the rock layers.

Actual breaking of the earth's crust is known as *faulting*. This is the third chief kind of tectonic deformation. The rock masses may be broken into blocks which are raised or lowered with reference to one another. The result is the formation of *block mountains* or of *rift valleys*. These tectonic forms are repeated in many parts of the world, the middle valley of the Rhine (Fig. 226), Death Valley in California, the Dead Sea–Red Sea rift, and the lakes of eastern Africa being a few well-known examples. Earthquakes are produced by the slipping which takes place along fault lines.

These tectonic forms are produced very slowly as measured by human time. The old popular phrase "convulsions of nature" implies

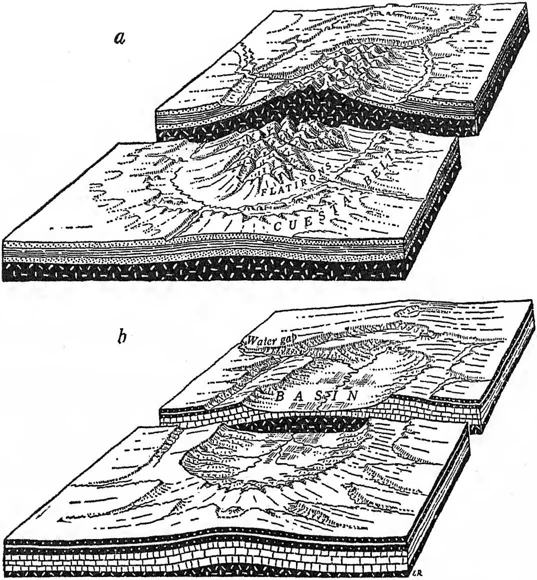

FIG. 225. *Block diagrams illustrating the landforms characteristically associated with the erosion of a structural dome;* (a) *where the rocks exposed in the center are relatively resistant;* (b) *where the rocks exposed in the center are relatively weak*

violent movements. In the last century, however, geologists have come gradually to realize that sudden spectacular movements are rare and that most of the deformations take place only very slowly. *Volcanoes,* however, the fourth type of tectonic form, are quite different.

3. **Volcanoes.** There are two chief kinds of volcanoes. Where the molten material which pours out from within the earth emerges quietly, a broad dome is piled up around the crater or fissure. One of

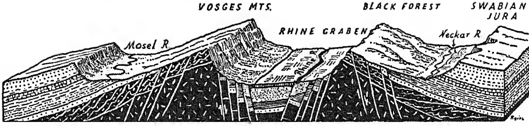

FIG. 226. *A generalized cross section of the rift valley of the Rhine and the adjoining block mountains of the Vosges and the Black Forest*[1]

the finest examples of the *dome volcano* is furnished by the island of Hawaii, which has been built up by successive flows of lava to a height of more than thirty thousand feet above the floor of the Pacific Ocean. Such volcanoes are not explosive, but the lava in them is of a kind which cools slowly and flows great distances after it has reached the surface.

The second type of volcano is explosive. It builds around its crater a cone composed of alternating flows of lava and falls of ash and dust. Of the *cone volcanoes*, Fujiyama in Japan is noted for the perfection of its form. The eruptions of cone volcanoes are violent and destructive. Vesuvius, for example, after lying dormant for many centuries, in the year 79 A.D. suddenly blew its old cone to pieces and built a new one inside the rim of the old one. At this time the neighboring towns of Pompeii and Herculaneum were destroyed, the former being buried under from 25 to 30 feet of ash and dust. Another striking example of the explosion of a long-dormant conical volcano is that of Krakatoa, formerly located on an island in Sunda Strait, between Java and Sumatra. In 1883, with but little warning, it exploded violently, with a concussion which was heard in Australia, 2200 miles distant. About two thirds of the mountain was blown away, and the water under the spot where the central peak had stood was found to be 1000 feet deep after the explosion. Enormous "tidal" waves produced by this cataclysm were very destructive. Dust was blown 20 miles into the air and in the course of a few weeks drifted entirely around the world, giving vivid colors to the sunset skies. Dust from Krakatoa has been identified on the snow surfaces of the polar regions.

[1]Based on a sketch by Penck, from R. D. Salisbury, *Physiography*, New York, 1909.

II. Destructional Forms

4. **The Destructional Forms.** As soon as the tectonic forces begin to raise a portion of the earth's crust above the sea, the exposed land is attacked by various processes of destruction. Since these processes result from the contacts with the atmosphere, the particular combination of processes in any one area is largely controlled by the climatic conditions. All these processes, however, in the long run have the effect of reducing the elevations and filling the low places of the lithosphere. Erosion proceeds by *weathering* (rock fracture and decay), *corrasion* (wearing away of exposed surfaces), and *transportation* (movement of loose material). Corrasion and transportation can be accomplished in six different ways, each of which produces a peculiar set of landforms. These six processes are (1) running water, (2) direct action of gravity on slopes, (3) glaciers, (4) wind, (5) solution, and (6) waves and currents. We shall consider in turn the landforms produced by each of these.

5. **The Products of Weathering.** The first step in the wearing down of the land is the breaking up of solid rock into pieces under the influence of the atmosphere. This is known as weathering. It proceeds by two different methods: the rocks are physically broken, or *disintegrated*; or the rocks are attacked chemically and the minerals are transformed, or *decomposed.* Disintegration is hastened by the expansion and contraction which come from heating and cooling, or by frost action, or, to a lesser extent, by the prying action of tree roots or the burrowing of animals. The physical fracturing of the rocks reaches a maximum in the deserts, where there is a great contrast between the temperatures of day and night, and in the polar regions or high mountains, where frost action is most active. Decomposition requires the presence of water, and since most chemical processes go on more rapidly at higher temperatures this type of weathering is most active in the rainy tropics.

The result of weathering is the production of a mantle of loose material at the surface of the earth. This mantle is more or less thick, depending on the strength of the weathering processes, the resistance

of the rock to these processes, the length of time the rock has been exposed to them, and the rate of removal. Such a mantle of loose material is known as *regolith.* The regolith which is chiefly the result of disintegration is generally coarse, whereas the mantle produced by decomposition is generally fine.

6. **Landforms Produced by Running Water.** In most parts of the world the landforms produced by running water are of dominant importance. Where this is the case the surface features may be described under four headings: the valleys, the interfluves, the stream pattern, and the relief. Sections 7 to 19, inclusive, deal with these elements as produced by running water.

7. **V-Shaped Valleys.** When a portion of the earth's crust is raised rapidly enough and far enough above the sea, the streams of water which flow over its surface cut rapidly downward and headward to excavate V-shaped valleys. The slope of the stream channel in such valleys is steep and is usually interrupted by falls and rapids. However, as the stream cuts down in the valley bottom, the sides of the valley are changed both by the movement of regolith on the steep slopes and by the headward cutting of tributaries. The transverse profile of the valley depends on the ratio between the rate of downward cutting of the main stream and the rate of valley-side erosion. Where erosion on the valley side is relatively slight, as in the dry lands, the V is narrow and canyon-like; but where the valley-widening processes are very active, as in the rainy tropics, especially where the forest has been removed, the V becomes broad and open. In all V-shaped valleys the stream occupies the whole bottom (Figs. 84, *a* and 227, *a*).

8. **Baselevel and Grade.** However, streams cannot cut down their valley bottoms indefinitely. No stream can cut below the body of water into which it flows; nor can any stream reduce its valley bottom to the level of the body of water into which it is flowing, except at its mouth, for it must maintain a slope on which to flow. The level below which a stream cannot cut at its mouth is known as *baselevel.* After the stream reaches baselevel at its mouth, little by little it establishes a slope on

which it is just able to flow. An equilibrium is reached between three variable elements: slope, volume of water, and load. A change in any one of these elements necessitates readjustment of the others to maintain this equilibrium. When a stream has developed this balance, it is said to be *graded*.[1]

9. **Floodplain Scroll Valleys.** The valleys remain V-shaped until the streams establish grade. But as soon as downward cutting ceases, the streams must expend their energy in lateral cutting at the base of the valley sides. At each river bend the current swings against the outside bank, and by *sapping*, or undercutting, it pushes back and steepens the valley side. The lateral movement of the river, however, leaves exposed a small piece of flat valley bottom on the inside of each bend. The first bits of valley flat to appear are scroll-shaped in outline (Fig. 227, *b* and *c*). As the river swings from one side of its valley to the other, the scrolls appear on alternate sides, each of them isolated by the river and by the steep valley slopes behind them. Since these flats are submerged during flood water, they are included under the general term "floodplain," or that portion of the valley bottom covered by water during flood. Valleys of this kind are called floodplain scroll valleys.

10. **Floodplain Valleys.** All stages of gradation may be seen between the floodplain scroll valley and a third type, the floodplain valley. Little by little the valley sides are pushed back and the floodplain scrolls become more extensive. From the somewhat irregular swings of the river in its earlier stage, more regular meanders are gradually developed, the width of these meanders being proportional to the size of the river. Since the meanders tend to migrate downstream, they not only cut against the valley slopes on the outside of each bend but they also begin to undercut the upstream side of each spur which, in the floodplain scroll valley, extends from the valley slope into the inside of each river bend (Fig. 227, *d*). When the spurs are eliminated, the flats lose their scroll-shaped outline and become continuous, and the river is able to meander freely across a wide and unobstructed floodplain (Fig. 227, *e*).

[1]For classical discussions of these concepts see references 7 and 18; for more recent studies which modify many of the older ideas on this subject see references 3 and 22.

A number of distinctive features characterize valleys of this type. The floodplain is bordered by sharply defined *valley bluffs*, which are especially steep where the river swings against them (Fig. 227, *f*). Since the floodplain is covered at high water, it is built up of the loose silts and sands deposited by the water and known as *alluvium*. During a flood the greatest amount of deposition takes place along the immediate edges of the channel, for here the largest checking of the current is felt. In the course of time the edge of the channel is built up higher than the rest of the plain. These highest parts of the floodplain, the last to be covered by water in time of flood, are called *natural levees*. Back from the channel, near the margins of the floodplain, are the lowest places—the *back marshes*, which may remain wet even during low water (Fig. 86).

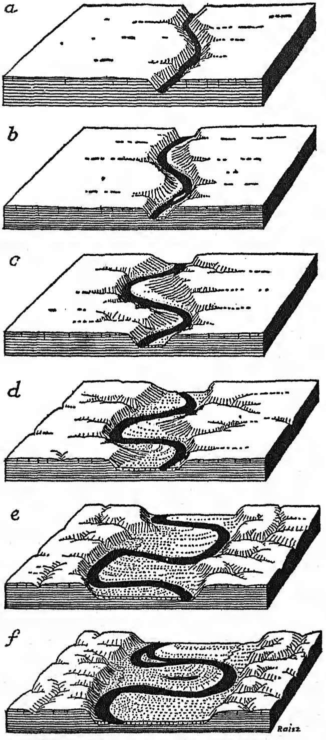

FIG. 227. *Series of block diagrams illustrating the stages in the evolution of a valley from youth to old age*

All these various features of river floodplains are arranged in crescentic patterns. Rivers seldom flow in straight lines, unless controlled by man; on a floodplain they meander, and not uncommonly whole meanders are cut off during high water,

and the river channel is shifted to another position. As a result the typical floodplain is marked by a confused array of abandoned channels, or oxbow lakes, each bordered by natural levees, and all arranged in characteristic crescentic plan (Fig. 87).

11. **Interfluves.** During the development of these various types of valleys the interfluves also pass through a sequence of forms. At first much of the initial surface of the land remains undissected. The land between the main V-shaped valleys is flat-topped, and the divides between neighboring streams are ill-defined or entirely absent. As the valleys are widened and as the tributaries cut headward, eventually the interfluves are dissected, and a sharp divide is established between neighboring drainage basins. The interfluves are no longer flat-topped, but are cut by many small steep-sided valleys, with more or less sharply crested ridges separating them. In the course of time, however, these ridges are lowered—first by the cutting of the tributaries and later by the creep of the loose material which mantles the slopes. Finally only low, rounded swells separate the drainage basins (Fig. 84).

12. **The Cycle of Erosion.**[1] The succession of forms developed during the wearing down of an upraised surface toward baselevel is called a cycle of erosion. During such a cycle the landforms pass through stages known as *youth, maturity,* and *old age.* When the streams are flowing in V-shaped valleys vigorously and turbulently, and when the interfluves are still flat-topped and the divides ill-defined, the landforms are said to be youthful. When grade is established and the floodplain scroll valley makes its appearance, and when the headward erosion of the tributaries sharpens the divides so that none of the initial surface is left undissected, the landforms are said to be mature. Then, as the valleys develop broad floodplains and the interfluves are worn down to low swells, the landforms are said to be old.

Theoretically this last stage of the cycle of erosion, as the land is brought closer and closer to baselevel, is a long one. Land which has been reduced almost to baselevel but which still has a few remnants of erosion, or *monadnocks*, standing above the general surface, is called a

[1]Chapter VIII of reference 7, and references 8 and 9.

peneplain.[1] The forms of old age normally appear first near the mouth of a stream and extend gradually headward. However, studies of landforms indicate that there are only a few peneplains in existence in the world today lying in the position in which they were formed; on the other hand, many upraised and dissected peneplains have been described. This seems to be an indication that the more recent geologic periods have been characterized by considerable instability of the continents, and that these have taken on their present outlines only recently. A well-developed peneplain can come into existence only when the land stands still in its relation to the sea for a very long period of time. The renewed uplift of the land during an incompleted cycle of erosion results in the interruption of that cycle and in the *rejuvenation* of the streams, which produces youthful forms within the more mature forms.

13. **Associations of Valley and Interfluve Forms.** This simple sequence of landforms is infinitely complicated in fact by variations in the rate and kind of earth movements, by variations in the rock resistance and structure, and by other circumstances. Theoretically, for instance, there are nine possible combinations of the three valley types and the three interfluve types. Where the uplift of the land which initiates a cycle of erosion is slight, so that baselevel lies only a short distance below the initial surface, the streams may develop floodplain scrolls and so advance their valleys to maturity or even old age while the central portions of the interfluves remain undissected and youthful (Fig. 228, *a*). On the other hand, if uplift is very great or if it is continuous, the interfluves may develop the sharp divides of maturity while the streams are still deepening their youthful V-shaped valleys (Fig. 228, *b*). All the various stages between these extremes may be observed in different parts of the world.

14. **Some Complex Valley Forms.** As a result of various kinds of earth movement, or from other causes which we cannot discuss here, valleys of greater complexity are developed. Since the cycle of erosion can be interrupted at any stage, valleys may be composite in character. For example, the rejuvenation of an old stream results in the preserva-

[1]Chapter XVII of reference 7.

tion of the meanders of old age in the youthful V-shaped valley which follows; in other words, it results in the development of *intrenched meanders.* Or a wide mature valley, if rejuvenated, may be transformed into a valley with an upper flare and lower V. On the other hand, valleys may become *aggraded*: a decrease of slope (by depression of the land instead of uplift), a decrease of the volume of water, or an increase of load may cause a stream to fill up its valley bottom. Aggraded youthful valleys are especially noticeable because of the contrast between the steep valley sides and the flat bottom. This is a valley type which is very common in the desert, where many streams flow only after a rain and most of the time are dry.

FIG. 228. *Valley and interfluve profiles;* (a) *youthful interfluves and mature valleys;* (b) *mature interfluves and youthful valleys*

15. Complex Valleys Produced by Rock Structure. Where valleys are being excavated through stratified rocks of varying degrees of resistance the stronger layers project on the valley sides as cliffs. If the strata lie in a horizontal or nearly horizontal position, the *cliff and platform* type of valley is produced; if the strata are inclined, the valleys between the outcrops of resistant layers become *asymmetrical.*

16. Interfluve Forms Produced by Rock Structure. The forms of the interfluves are similarly affected by the rock structure (Fig. 229). Horizontal strata produce flat-topped interfluves, or *mesas.* Tilted rock layers produce ridgelike *cuestas.* The erosion of a dome structure produces a series of infacing cuestas (Fig. 225), whereas the erosion of a structural basin produces a series of outfacing cuestas.[1]

17. Stream Patterns. The third of the four major headings under which landforms produced by running water can be described (sect. 6)

[1]Some writers prefer to distinguish between steeply sloping ridges, where the rock layers are very steeply inclined and are called *hogbacks*, and ridges where one slope is scarcely distinguishable, so gentle is the dip of the resistant stratum. They reserve the term "cuesta" for this latter type (reference 27).

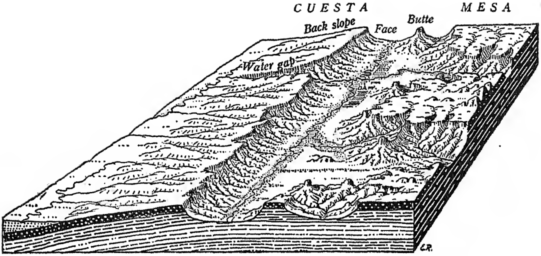

FIG. 229. *Block diagram illustrating the characteristics of mesas and cuestas*

is the stream pattern. The arrangement of the valleys and interfluves is a function of the stream pattern. The commonest type of pattern, developed where the rock structure does not interfere with the free development of the streams, is *dendritic*; that is, branching like a tree (Fig. 230, *a*). Around a dome the dendritic pattern can be arranged in radial fashion, but elsewhere the main streams may lie roughly parallel to one another. The dendritic pattern is first elaborated and later simplified during the cycle of erosion: in youth the main streams are relatively straight, with few and only short tributaries; in maturity the fullest development of the drainage is reached, with many small tributaries joining the larger main stream and with numerous examples of drainage rearrangement resulting from the capture of one stream by the tributaries of another; in old age only a few master streams have survived the competition, and these are large, with a few large tributaries.

The second type of drainage pattern is formed where rock strata of varying degrees of resistance are inclined at an angle, so that the more resistant beds come to the surface to form cuesta ridges separated by asymmetrical valleys. Because of the relative ease of stream erosion on the weaker beds, the valleys are quickly excavated along the outcrops of these strata between the upstanding cuestas. The main streams may cross the ridges through deep, relatively youthful water gaps. The resulting drainage pattern is one of striking parallelism—of long, straight valleys, in strict accordance with the arrangement of the rock

strata, joined by short right-angled jogs where the rivers cross the resistant beds. This is known as *trellis* drainage (Fig. 230, *b*).

Where the cuestas are arranged around the margins of a dome in circular plan, the trellis pattern is curved and is described as *annular*.

18. **Relief.** These various features developed by running water may be constructed in various degrees of relief. They may occur in miniature in a plain where the relief is slight, or they may be built on a grand scale in a mountain region with very high relief. There is no essential difference in form between the Grand Canyon of the Colorado and the gully which develops in a plowed field after a heavy rain.

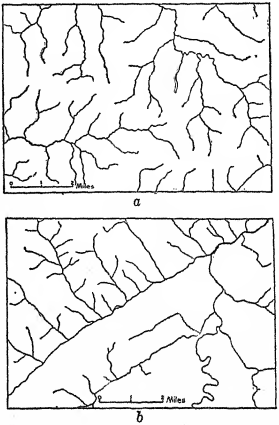

FIG. 230. *Stream patterns;* (a) *dendritic;* (b) *trellis*

During an uninterrupted cycle of erosion the surface is changed from one of slight initial relief to one of considerable relief, and again to an ultimate surface of slight relief. As soon as the main streams feel the effects of rejuvenation they start the work of downward cutting. During youth, therefore, the local relief is gradually increased. The amount of this increase in the long run depends on the depth of baselevel below the surface; in other words, on the amount of uplift. The maximum relief is reached when the interfluves become mature, when the tributaries have extended headward to dissect the last remnants of the initial surface. After the streams become graded the relief gradually decreases as long as the land remains undisturbed by earth movements.

19. **Landforms Developed in Arid Climates.** Even in dry climates the sculpturing by running water is of dominant importance in producing landforms. The rare but violent desert rains give rise to floods which do

the work of erosion and deposition quickly. The chief contrast with the work of running water in rainy lands, however, is the absence of a regional baselevel. Since most desert streams do not reach the ocean, they can carry material only from the higher surfaces into the desert basins, or *bolsons*. The waste products are not removed from the region as a whole, but are accumulated not far from their point of origin. The sequence of desert landforms therefore consists of the vigorous erosion of the elevations and in the gradual accumulation of a great sheet of alluvium. At first the mouths of the valleys are marked by *alluvial fans* where they enter the basins. Later these coalesce to form a continuous compound alluvial fan around the piedmont. At this stage the landforms consist of three chief parts (Fig. 231, *b*): (1) the rapidly crumbling mountains, deeply dissected by youthful streams; (2) the gentle slopes of the alluvial fans, which emerge from the mouths of the valleys and extend toward the center of the bolson in long, sweeping curves; and (3) the *playa*, or the salt-incrusted flat at the center of the bolson, in which water may accumulate temporarily after the heavy rains in the mountains.

As the desert sequence continues, the bolson is gradually buried beneath the advancing fans. In some cases a higher bolson may be dissected by streams leading to neighboring basins at lower levels (Fig. 231, *c*). In the late stages, however, the bolson is filled with a great sheet of waste material, while the mountains are reduced to rocky pediments thinly mantled with the fans and surmounted here and there by a few island-like *inselberge*, the mountain remnants.[1] These rocky platforms are called *hamadas* (Fig. 231, *e*). Wind action reaches a maximum in these areas (see section 30).

20. **The Direct Action of Gravity on Slopes.** The direct action of gravity on slopes is the second of the six chief processes of corrasion and transportation. The movement of the regolith on the slopes begins as soon as the streams develop valley sides and the interfluves are dissected by tributaries. The effect of this movement is to change the interfluve profiles from the sharp concavity of running-water excavation to a rounded convexity.

[1]Reference 11.

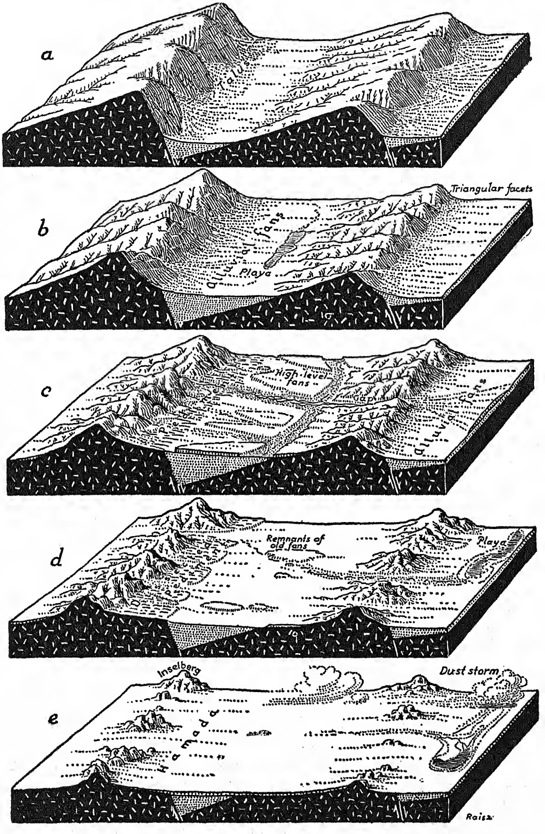

FIG. 231. *Series of block diagrams illustrating a sequence of landforms in an arid climate*

Three kinds of regolith movement can be observed, which we shall describe as *creep*, *flow*, and *slide*. Earth creep is perhaps the most common of these. Any occurrence which causes the waste mantle to expand produces a movement out at right angles to the slope, and the subsequent contraction then takes place under the influence of gravity directly downward. The result is a gradual downhill movement. Wetting and drying produce rapid earth creep, and earth creep is at a minimum in those climates where the ground remains either permanently dry or permanently wet. Freezing and thawing are also active aids of earth creep. The presence of burrowing animals is another but quite different cause of creep.

Earth flow is a smooth, downward semiliquid movement, generally restricted to the waterlogged regolith of the rainy tropics. The effect of earth flow is to produce concave rather than convex slopes.

The presence of trees tends to retard both flow and creep, and so to maintain steeper slopes than would otherwise form. The gentlest slopes of the old-age interfluves would theoretically be developed in the tropical grasslands, where wetting and drying would be extreme and yet where no retaining network of tree roots would hold back the movement of regolith.

The third type of regolith movement is generally limited to mountainous areas. This is the slide, or *avalanche*. Where the geologic structure is favorable the loose regolith forming on the steep slopes stands perilously balanced until some slight jar gives it a start. Slides are most common in the spring in middle-latitude mountains, when the frost begins to melt and when there is plenty of water to aid the movement. Slides occur more frequently on shady slopes where the ground does not dry out quickly. Starting high up, perhaps with a single boulder, a larger and larger mass of the waste mantle begins to move. With destructive violence the avalanche rushes into the valley bottom, forming there a jumbled accumulation of boulders and broken tree trunks, arranged in a series of low concentric ridges, perhaps blocking the stream to form a temporary lake. The *avalanche scar* on the valley side and the pile of debris below are forms often repeated in mountain areas (Fig. 167). Man sometimes creates avalanches through oversteeping slopes by excavating for roads, railroads, and canals.

21. **Glaciers.** During a recent period of geologic history somewhat cooler and stormier climates produced great accumulations of ice in various parts of the world. This period is known as the *Pleistocene.* In order to produce glaciers it is necessary that more snow should fall during the winter than is melted during the summer; heavy snowfall and cool summers, then, are the climatic conditions which lead to glaciation. As the snow piles up to greater and greater depths, ice is gradually formed underneath. As this ice increases in thickness, it tends to spread, either downhill, if it lies on a steeply inclined slope, or out in all directions from a center of accumulation, if it lies on a flattish surface. In this way the great ice sheets came into existence. In the course of long periods of time, as measured by human standards, the ice grew to great thicknesses and extended by further accumulation in the directions of heavier snowfall. Near the margins of the ice sheets, at least, there was considerable outward movement, and the resulting grinding and scraping over the hills and through the valleys of the preglacial surfaces brought about important changes in the character of the landforms.

The distribution of the ice sheets during the Pleistocene is shown in Fig. 143. At present large ice sheets exist only in Greenland and Antarctica; but high mountains, even on the equator, have smaller glaciers.

22. **Forms of Glacial Erosion by Ice Sheets.** In hilly areas the work which the ice accomplished was largely that of erosion. The loose rock material at the surface was scraped off and dumped into the valleys as irregular masses of heterogeneous debris. The bedrock, exposed on the preglacial ridges, was smoothed, rounded, and polished. Passing over a preglacial hill, the scraping action of the ice was concentrated on the side toward which the ice was moving. The contour of the hill was smoothed and rounded; but on the lee side, where the ice, in moving away, plucked from the slopes any loose or broken fragments of rock, steep, jagged cliffs were formed. The characteristic *rock hill* of a glaciated upland therefore has a relatively gentle slope in the direction from which the ice came; a rounded summit, composed in many instances of bare, smooth rock; and a jagged cliff on the lee side. Many of the preglacial valleys, however, were completely filled with the rock debris scraped from the hills. Except for the rock hills, the ice left such

hilly country rougher than before, although, perhaps, with less total relief; and with the melting back of the glacier, the many small depressions, produced both by ice gouging in bedrock and by irregular deposition, were left as lakes and marshes.

23. **Glacial Deposition.** The enormous amount of debris picked up and carried by the ice was deposited on the lowlands, and, especially near the margins of the glaciated area, forms a covering in some places hundreds of feet deep over the preglacial surface. As long as the climatic conditions over the glacier favored snow accumulation, the ice itself, at least near the margins, continued to move outward in great tongues, or lobes. The actual position of the margin of the glacier, however, was dependent on two things: the rate of advance and the rate of melting. If the summers were cool and the melting slow, the ice front would advance; but if the summers were warmer, melting might go on so much faster than the rate of advance that the actual front of the ice would retreat. Cycles of wetter and drier and hotter and cooler years apparently prevailed during the glacial period, as they do now, for the ice advanced and retreated many times, and the rate of advance and retreat was very irregular.[1]

24. **Moraines.** Along the glacier front, where melting was active, the rock debris contained in the ice was dropped in irregular piles. If the rates of advance and melting were balanced and the ice front remained stationary for a period of years, a belt of little hills was built up, following the lobate pattern of the ice margin (Fig. 232). These hilly belts are called *moraines.* In some cases the moraines had extremely rough surfaces, composed of knobby hills and deep depressions—described as *knob and basin moraines.* In other places only *sag and swell moraines* were formed. Moraines are best developed on plains, and near the margins of the glaciated areas where the supply of rock material was large.

25. **Outwash.** Moraines were deposited directly from the ice, but much of the material carried by the melting glaciers was spread out by floods of water. Glacial outwash filled in around the moraines and

[1]Reference 17.

buried the pre-existing landforms under a mantle of water-laid sands and gravels even beyond the limits of the ice.

The water which poured from the melting glacier deposited its load under three different sets of circumstances. Where the valleys sloped away from the front of the ice, as in the case of the Mississippi system, ready-made drainage channels were provided, and the floods were concentrated in them. Hundreds of miles beyond the limits of glaciation the floods of glacial waters filled the valleys. Broad floodplains were developed as the reinforced streams advanced their valleys more rapidly than their smaller tributaries in the cycle of erosion. Such outwash deposits are called *valley trains.* Except for the prematurely old main valleys, this type of outwash has not greatly modified the preglacial landforms.

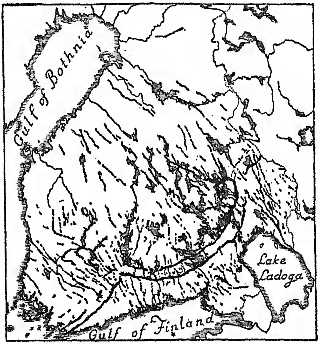

Fig. 232. *The two large moraines and the chief eskers of Finland.* (After J. J. Sederholm)

On the other hand, in areas where surfaces without adequate preglacial valleys lay beyond the melting ice, the torrential waters were not concentrated. They spread an apron of sand or gravel in front of the moraine. The resulting plain, sloping gently away from the former position of the ice front, is called an *outwash plain.* Not uncommonly such surfaces are pitted with innumerable small depressions, resulting from the subsequent melting of ice masses buried under the sands. When an outwash plain has been deposited over a country previously mantled with moraines, landforms of the most varied kinds are mixed together in heterogeneous confusion.

26. **Glacial Lakes.** A very different situation was presented when the water found a surface sloping toward the ice instead of away from it.

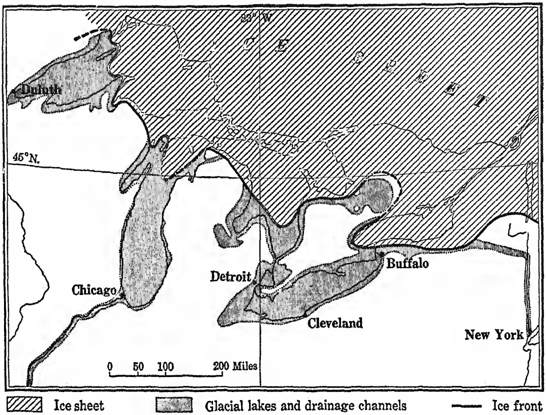

FIG. 233. *A stage in the retreat of the last ice sheet from the Great Lakes region, showing formation of glacial lakes ponded against the ice front, and the temporary drainage channels by way of the Illinois and Mohawk rivers.* (After F. B. Taylor)

In this case a lake was formed, with one side held in by the ice itself and with an outlet over a low place in the divide. The present Great Lakes of North America are bordered by lake plains which were formed in this way when the outlet through the St. Lawrence River was blocked (Fig. 233).[1] The lake waters spread over much of northern Ohio and eastern Michigan, finding outlets at various times through the present site of Chicago to the Illinois River and through the Mohawk Valley to the Hudson. Similarly, when the outlet to Hudson Bay was blocked, the waters of the Red River of the North were ponded in the basin of the present Lake Winnipeg. A glacial lake, referred to as Lake Agassiz, extended southward along the Red River Valley as far as the northern part of South Dakota. The lake plains are among the flattest surfaces in existence in the world; and in glaciated regions they provide exceptionally good agricultural lands.

[1]Reference 26.

27. **Other Glacial Forms.** In addition to these widespread forms of glacial deposition, there are a number of more unusual forms, which, nevertheless, are of great importance locally. The *drumlins* are rounded, elongated hills which loom conspicuously above their surroundings and are composed of an unstratified mixture of boulders and clay. *Kames* are small, knobby hills of stratified sand and gravel, commonly associated with moraines and not easily distinguished from morainic hills by surface form alone. *Eskers* are long, narrow ridges of irregular height, some of which can be traced for scores of miles across the country (Fig. 232). They are composed of coarse gravels with faint stratification and are believed to mark the courses of subglacial streams.

28. **Glacial Forms in Mountains.** Glacial forms in mountains differ in many ways from those produced by continental ice sheets. Since the glaciers are mostly confined to the valleys, the ice erosion results in a sharpening of the peaks and a steepening of the valley sides. The *glacial trough* is the most striking feature developed by valley glaciers. Here we find that whatever the preglacial form of the valley, the ice gouges it out, scraping away the spurs, steepening the sides, and deepening and widening the bottom. The characteristic profile of a glaciated valley is that of a flattened **U**. The deep excavation of the main valley leaves the former tributaries perched high on the cliffed sides as *hanging valleys* (Fig. 234, *d*). In the bottom of the trough horseshoe moraines, marking the places where the ice front hesitated during its retreat, act as dams to hold back little valley lakes. Where the glaciers were big enough to reach the piedmont and spread terminal moraines on the neighboring lowlands or gouge out rock basins in the valley bottoms, large *marginal lakes* were formed, extending up-valley for many miles. A number of these lakes appear on the map of the southern Andes (Fig. 166); they are common in other parts of the world where similar alpine scenery has been developed,—for example, the lakes of the southern Alpine piedmont in Italy (Fig. 190).

The most spectacular alpine scenery, however, is produced at higher altitudes. The snow field in which the ice of a valley glacier has its origin is commonly located high on the mountain slopes at the valley head. As the ice forms and moves off downgrade it plucks away the

rocks loosened by frost. The plucking action, quite similar to that which takes place on the lee side of a rock hill covered by a continental ice sheet (sect. 22), results in the hollowing out of an amphitheater backed by steepened cliffs. Vigorous glaciation produces great semicircular amphitheaters near the mountain crest at the head of each valley. In many cases small remnant glaciers still survive at these high levels; but where the ice has melted entirely away the almost vertical rock walls overlook the exposed floor of the basin, in which is nestled, among the smoothed and polished rocks of the glacier bed, a little lake of crystal-clear, ice-cold water. The lake occupying such an ice-gouged basin is called a *tarn*; the whole amphitheater is known as a *cirque* (Fig. 234, *d*).

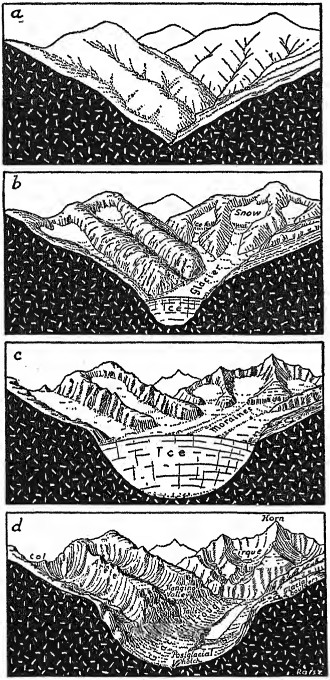

Fig. 234. *A series of diagrams illustrating the development of glacial landforms in high mountains*

The sculpturing of the mountain crests by the headward erosion of the cirques develops a jagged skyline. Glaciers gouging out their amphitheaters on opposite sides of a range push back the head walls until only a knife-edge of crumbling rock separates them. Here the divide is lowered to form a *col*. Knife-edge divides, or *arêtes*, also separate the

neighboring cirques on the same side of the range. Meanwhile between the cols, and towering high above the neighboring cirques, stand massive pyramids of frost-fractured rock. These are the *horns* which produce the characteristic "saw-tooth" sky line of alpine scenery.

29. **Postglacial Mountain Forms.** Since the glacial period a deluge of rock fragments from the towering walls of the cirques and horns has partially obscured the glacial forms in some localities. Frost action at high altitudes is very active. Especially in the spring large quantities of broken rock fall from the cliffs and accumulate as *talus cones* at the base. Loosened fragments of rock break off and clatter noisily down into the valley. In some of the cirques the accumulation of waste is so great that huge *rock streams* are formed, descending into the amphitheater bottoms and filling them with a tumbled confusion of rock piled on rock.

30. **Landforms Produced by Wind.** Landforms produced by wind are of much less importance than those developed by the processes already discussed. Wind erosion can be effective only where there is a supply of dry sand or dust to abrade the exposed rock surfaces. In the dry lands, especially in the late stages (sect. 19), wind-sculptured forms are not uncommon, but elsewhere they are rare. Wind sweeping over the fans of the desert bolsons, or over the ergs which succeed them in the dry-land sequence, picks up whatever loose material is available. Some of the material is too heavy to be carried far; this is rolled or skipped into dunes. The very fine particles, however, are lifted high into the air and may even be carried beyond the limits of the deserts. Great accumulations of fine wind-blown material, known as *loess*, are found on the lee sides of the world's great deserts. The removal of the finer particles from the desert fans is known as *deflation*. Little by little the surface comes to be mantled with only the coarser pieces which are too large to be moved by the wind. These fragments are fitted tightly together to form what is known as the *desert pavement.*

Dunes are also formed in rainy lands where a large supply of dry sand is available, as along a sea or lake shore.

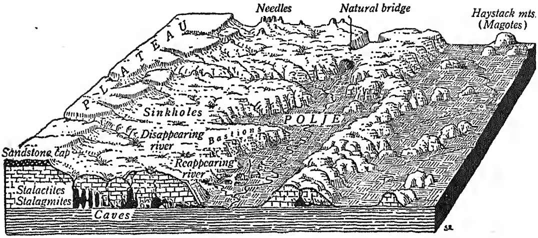

Fig. 235. *Block diagram illustrating some characteristic karst landforms*

31. **Karst.** Landforms resulting from rock solution are also narrowly limited in their distribution. Only certain kinds of rocks are sufficiently soluble to permit such development. Of the soluble rocks, limestone is the chief kind, although not all limestones are soluble and each limestone layer is of a somewhat different degree of solubility. Where solution can go on rapidly enough, caverns are formed underground; and the collapse of the cave roofs marks the surface of the earth with pitlike depressions, or *sinks* (Fig. 235). The surface streams find entrance into these underground caverns and disappear, leaving only dry valleys above ground. Such areas may, as a result, be deficient in moisture at the surface. Lands pockmarked in this way with sinks are called *karst* lands after the type locality where such forms are developed on a spectacular scale, on the Karst Plateau, near the head of the Adriatic Sea in Yugoslavia (Fig. 190).[1]

32. **Shorelines.** The relative changes of level between the land and the sea are most noticeable along the shores. So unstable are the relations of land and sea and so rapid are the processes of shoreline development by waves and currents that these modifications can be observed in historical time. Many are the ancient seaports which now are separated from open water by miles of delta or coastal plain.

In general two major classes of shorelines may be recognized. There are *shorelines of submergence* and *shorelines of emergence.*[2] The for-

[1]See reference 12. [2]Reference 24.

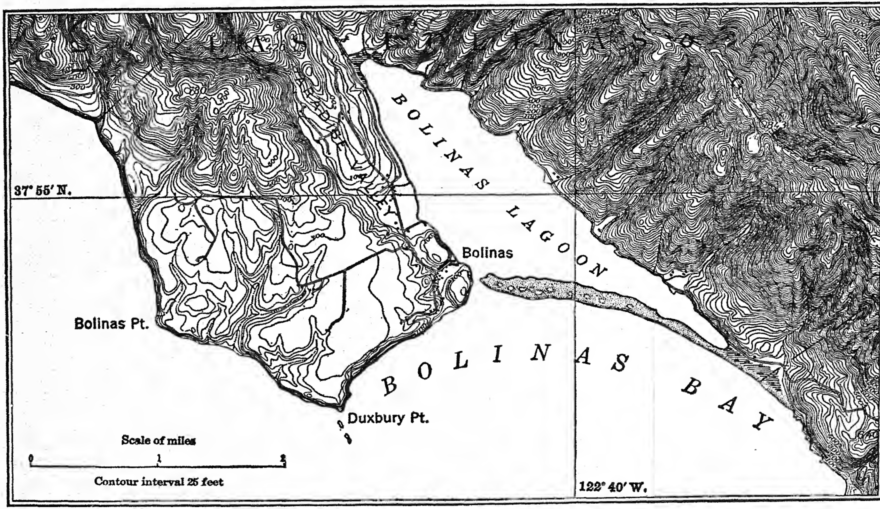

Fig. 236. *A portion of the coast of California—a shoreline of recent emergence following local subsidence.* (From Tamalpais quadrangle, California, United States Geological Survey)

mer class is the result of either a depression of the land or a rise of the water; it is characterized by a greatly indented shore, with numerous bays, inlets, promontories, and islands. Where pre-existing river-cut valleys are drowned by submergence, leaving the interfluves to extend seaward as promontories or strings of islands, the descriptive term *ria shore* is used (Fig. 38). Where a glacial trough is submerged, the result is described as a *fiord* (Fig. 166). The shorelines of emergence, on the other hand, are relatively straight, with few indentations or promontories. Commonly these are *coastal-plain shores*; but in some places mountainous shores are emergent, in which case the land rises abruptly from the water's edge. Evidences of emergence can be seen in the raised terraces (see section 33) now well above the sea level (Fig. 236).

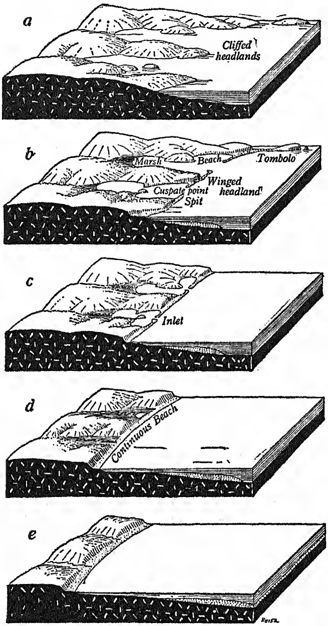

FIG. 237. *A series of block diagrams illustrating the development of a shoreline of submergence*

33. Shore Modifications. The waves and currents along shores produce rapid changes on the land. The formation of terraces is one of the most important of these modifications. Actual cutting by the waves is confined to a horizontal zone between the wave crests at high tide and the wave troughs at low tide. This zone of cutting, however, results in the development, by sapping, of a steep *wave-cut cliff.*

Under the water, and not visible unless raised on an emerging shore, is a *wave-cut terrace*, continued on its seaward edge by a *wave-built terrace* composed of the material cut from the land.

Whether shorelines are emergent or submergent, in the long run the waves transform them into shores of very similar appearance. The accompanying diagrams illustrate the sequence of forms of a shoreline of submergence (Fig. 237). First the promontories are cliffed, and then spits and bay-head bars appear across the indentations. Beaches are eventually formed across the mouths of the bays, festooned from headland to headland and enclosing half-moon-shaped marshy lagoons. Later the headlands are farther worn back and the bays filled until a straight shore is produced. A shoreline of emergence (Fig. 238) is quickly protected by an *offshore bar*, behind which a lagoon forms. In the rainy tropics this lagoon, like the smaller lagoons of the indented coast, is filled with mangrove, but in the middle latitudes it is commonly covered with salt-marsh grass. Little by little the bar retreats landward until eventually a straight shore again appears, with no lagoon. All these various stages can be observed on the shores of the lakes or the oceans.

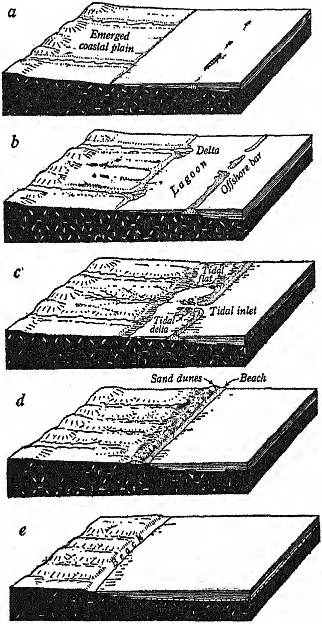

FIG. 238. *A series of block diagrams illustrating the development of a shoreline of emergence*

34. **Deltas.** The building of deltas by streams is dependent on various factors. Submergence and emergence are balanced against the rate of delta growth; and delta growth, in turn, is determined by the amount of alluvium brought by the river, by the nature of the body of water into which the stream is flowing, and by other things. Marked shore currents greatly affect the shape of the growing delta. As a general rule rivers entering seas with strong tides do not build deltas, for the washing of the water in and out of the river mouths keeps them free from silt. On the other hand, deltas form rapidly in seas with small tidal range, such as the Caribbean and the Gulf of Mexico or the Mediterranean.

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D · THE HYDROSPHERE

1. The Hydrosphere. Water covers 72 per cent of the earth's surface. It not only fills the major depressions of the earth's crust but also submerges the margins of the continents. The oceans are the reservoirs from which is derived not only the water that appears as a visible feature of the landscape in rivers, lakes, and marshes but also the invisible water vapor that plays such a vital part in determining the world's climates (Appendix B). Among the first recorded observations of mankind was the apparently strange fact that "the rivers flow into the sea, yet the sea is not full." The ancients were observing only the visible part of a cycle which is of fundamental importance among the natural processes of our earth. Water is evaporated from the surface of the ocean. Onshore winds carry the water vapor inland, where, later, it is deposited as rain, hail, or snow. When this water reaches the land, it returns again through the rivers to the sea, either directly or indirectly. Not only is the supply of moisture essential to living organisms on the earth, but also, of the six processes of land sculpture listed in Appendix C, only one, the wind, is neither directly nor indirectly dependent on the presence of water.

Two general facts regarding the hydrosphere should be remembered. The first is the peculiar range of the earth's atmospheric temperatures, which permits water to exist on the face of our planet in the form of a liquid. The second is the contrast between fresh and salt water with regard to freezing point and temperature of greatest density. Fresh water is densest at 39.2° F. If this were not true, lakes and rivers would freeze at the bottom instead of at the surface, and the circulation of water in them would be very different. Salt water with a salinity of 3.5 per cent freezes at 28° and also reaches its greatest density at this same temperature. As a consequence the deepest parts, which descend as much as six and one-half miles below sea level, are very cold.[1]

[1]For a general semipopular treatment of the oceans see reference 4 of this appendix. See also references 1 and 2 for a description of the tides and their distribution.

2. **The Nature of Ocean Water.** The water of the ocean is by no means uniform in character. There are great differences from place to place, and these differences are of fundamental importance not only in the geography of the oceans themselves but also in the climatic patterns of the whole earth. There are great differences in temperature—from temperatures well over 80° in the equatorial regions to temperatures below 32° in the polar regions. The highest ocean temperatures are in the Persian Gulf and the Red Sea. Where temperatures are high and evaporation is rapid, the salt content of the water is generally higher than it is in areas of low water temperature. Marine organisms are usually more abundant in cool or cold water than in warm or hot water. And associated with these things are the colors of ocean water, which range from greenish to bluish.

Generally, three major kinds of ocean water can be recognized. (1) In the high latitudes *polar water* is low in temperature, low in salt content, rich in plankton and other marine organisms, and greenish in color. (2) In the low latitudes the *tropical* and *subtropical water* is high in temperature, high in salt content, low in organic forms, and blue in color. (3) In between are the so-called *mixed waters* of the middle latitudes.

3. **Movements of Ocean Water.** As in the case of all phenomena on the face of the earth that are directly or indirectly related to the climatic features, there is a tendency toward symmetry in the pattern of arrangement. Departures from the symmetrical arrangement as regards ocean currents are due to the asymmetrical configuration of the continents and ocean basins. In both hemispheres there are two major lines of convergence where water masses differing in temperature, salt content, life forms, and color are in contact. These are known as the *polar convergence* and the *subtropical convergence* (indicated by black lines on Plate 23). In the Northern Hemisphere low latitudes the easterly winds produce a west-moving current of water, which, under the influence of the earth's rotation, tends constantly to swing to the right, or north. In the Southern Hemisphere the swing is to the left, or south. In the middle latitudes there is an east-moving current of water which, urged on by the prevailing westerly winds, swings to the right, or south, in

the Northern Hemisphere, and to the left, or north, in the Southern Hemisphere. These two currents of water in each hemisphere tend to swing toward each other, meeting along the lines of convergence. There is relatively little mixing along this line; rather, the denser water sinks under the lighter water.

The warm, west-moving currents of subtropical water strike the continental east coasts in the low latitudes. In the Pacific Ocean a strong equatorial countercurrent is developed, moving eastward between 5° and 10° north of the equator all the way to the coast of Panama and Colombia. In the Atlantic, on the other hand, the countercurrent which returns to the equatorial part of western Africa is relatively weak. The projecting nose of South America splits the west-moving current, deflecting a considerable part of it northward into the Caribbean and the Gulf of Mexico. This strong current of warm tropical and subtropical water emerges between Cuba and Florida as the Gulf Stream, which bathes the east coast of North America as far as about 40° north. It then swings eastward across the Atlantic as the North Atlantic Drift to the shores of Europe north of 35°. The configuration of Norway permits this relatively warm water to penetrate even into the polar ocean, bringing ice-free waters to the northernmost part of Europe. The similar current in the North Pacific, the Kuro Siwo, is not so strong and does not penetrate so far north. The configuration of Alaska and the Aleutian Islands does not permit it to reach the polar sea. The relative weakness of the Kuro Siwo can be matched against the relatively slight development of the equatorial countercurrent in the Atlantic.

The west coasts of the continents between 35° and 15° are bathed by relatively cold water. Here the equatorward-moving currents in both hemispheres tend to swing offshore. Close to the land, the water is being replaced by up-welling from below, and is especially cold.

Cold polar water moves equatorward along the east coasts of the continents in higher middle latitudes, and meets the east-moving water of the middle latitudes along the line of the polar convergence. The continental east coasts are bathed by cold water as far as 40° of latitude; and off the coast of eastern South America this cold water area is especially wide. These several currents are indicated and named on Plate 23.

The movements of water in the Indian Ocean are complicated by the seasonal shift of the monsoons. In the Northern Hemisphere winter there is a well-developed westerly movement of the subtropical water both north and south of the equator. These currents, striking the east coast of Africa, give rise to a strong equatorial countercurrent. In the Northern Hemisphere summer, on the other hand, the onshore south Asiatic monsoon reverses the direction of the ocean current north of the equator, and the equatorial countercurrent entirely disappears. The currents in the Bay of Bengal and among the East Indies are similarly reversed by the seasonal shift of the winds.

4. **Ground Water.**[1] Three things can happen to the water that falls on the surface of the land: it can evaporate again, it can run off over the surface, or it can sink into the ground. These processes are sometimes described as fly-off, run-off, and cut-off. The circumstances which increase or decrease evaporation have already been described (Appendix B). As regards the ratio between run-off and cut-off, the cut-off is greater where the regolith is porous than where it is relatively impervious, it is greater on gentle slopes than on steep slopes, it is greater when the rain falls slowly than when it comes in violent showers, and it is greater where the ground is protected by a cover of vegetation than where the ground is bare.

The water which sinks into the ground and is not used near the surface by plants fills the spaces between the rock particles of the regolith and even the cracks in the bedrock below. This store of water is known as *ground water*. The portion of the bedrock and regolith which is saturated with water is known as the *zone of saturation*, and the top of the zone of saturation is termed the *ground-water table*. Above the ground-water table is the *zone of aeration*, through which the cut-off must sink on its way down to the zone of saturation. Water on its way down through the zone of aeration is called *vadose water*. The zone of aeration, however, may be moist even when there is no vadose water actually seeping through it; for just as a blotter may remain damp but not saturated, the upper zone of the regolith may contain considerable *soil moisture*, even during a protracted drought.

[1]References 3 and 9.

The ground-water table lies at varying depths below the surface. In general it follows the contour of the surface but without the smaller irregularities. The water table rises under the hills and falls under the valleys, but it is farther below the surface under a hill than under a valley. Where the water table reaches the surface of the ground, it forms a marsh; where it rises above the surface, it forms a lake or supports the continued flow of a permanent stream. Even in the dry lands, where the characteristic streams flow only during and for a short time after a rain, ground water is usually to be found not far below the valley floors. Anything which diminishes the cut-off results eventually in a general lowering of the water table: thus the removal of the forest cover of a rainy land may result in the drying up of marshes and the fall of lake levels without any actual decrease in the rainfall.

The ground water in rainy lands seeps through the regolith toward the valleys to come to the surface again in springs. Because of the varied structure of the regolith and of the bedrock, the movement of ground water is not always uniform. The position and force of water in springs are determined by the underlying geologic structure.

5. **Common Wells.** The common well is used to tap the supply of ground water. It consists simply of an excavation deep enough to reach the zone of saturation. The ground water seeps into the well, filling it to the height of the water table.

6. **Artesian Wells.** In some wells water rises independently of the local ground-water table and may even flow out at the surface. These are *artesian wells*. The true artesian system requires the existence of a special set of geologic conditions the essentials of which are illustrated in the accompanying cross section (Fig. 239). A stratum of porous rock (*W*)—a sandstone, let us say—is inclined at an angle. Its outcrop is in an area of plentiful ground water (*C*). This is the intake of the artesian system, where the local ground water not only fills the usual cracks and fissures near the surface but also is absorbed by the porous sandstone. Gradually this layer of rock is saturated, and water seeps underground long distances, even hundreds of miles, from the intake. Overlying the water-bearing stratum is an impervious rock (*B*),—a

shale, for example,—through which the imprisoned water cannot make its escape. Thus when a fissure is found, or when man makes a boring, as at D_1, D_2, or D_3, the water rises under pressure until it reaches the level of E. In some cases the system is so placed that water actually flows out at the surface, making a flowing artesian well (D_2 and D_3); but in others the intake is not high enough for this, and the water only rises part way in the boring and must be pumped the remainder of the distance to the surface (D_1). The essential requirements for such a system are tilted layers of rock, among which there is a porous water-bearing stratum under an impervious stratum. Wells may be bored hundreds of miles from the source of water. Obviously, however, the overuse of such a system may remove water faster than it is stored up and may bring about the eventual exhaustion of the supply, as is threatened at D_1.

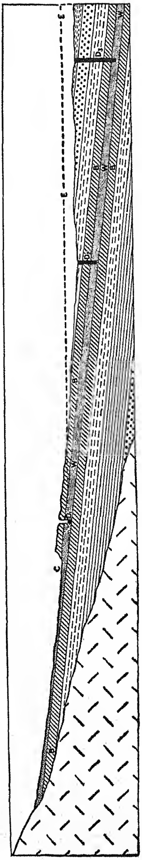

FIG. 239. *Diagram of an artesian system*

7. **Hot Springs and Geysers.** In many parts of the world there are natural springs the temperature of which varies from slightly warm to hot or even boiling. These are produced where the cracks and fissures in the bedrock are deep enough to bring the ordinary ground water in contact with heated rocks. Few cracks reach depths greater than five miles, but even at that distance below the surface the rock is very hot. Where pools of molten rock lie near the surface, as in volcanic regions, hot springs are common.

Geysers are less common. A geyser is produced in a fissure from which there is no outlet save at the top. Ground water seeping down into such an opening is heated at the lower end.

The temperature at the bottom may rise above the boiling point, but the weight of the overlying water does not permit the formation of steam. Eventually the superheated water below is able to force a passage up through the tube, blowing out at the surface in a tall plume of spray.

8. **Hard and Soft Waters.** As water sinks through the zone of aeration or seeps through the regolith to emerge again in the rivers, many minerals are picked up in solution. It is the constant addition of mineral matter to the oceans and to the desert lakes which have no surface outlets that gives such bodies of water their high mineral content. Waters which have a considerable amount of mineral matter in solution (chiefly $CaCO_3$, $MgCO_3$, and $FeCO_3$) are said to be *hard*. In general the ground water and the water in rivers is hardest in areas of limestone rock or on plains where movement is slow. The softest waters are found where the rocks are relatively insoluble, as in granitic areas, or in hilly or mountainous country where the runoff is too rapid to permit the dissolving of such mineral matter.

9. **Surface Water.** Surface water includes rivers, lakes, marshes, and glaciers. The landforms related to these kinds of surface water have been discussed in Appendix C.

The more or less regular rise and fall of streams with the passage of the seasons is known as the *regimen*. Regimens may be described as regular, irregular, or intermittent. The regimen of a stream bears a close resemblance to the rainfall of its drainage basin, but it is also controlled to a certain extent by a number of other factors. De Martonne[1] illustrates the factors in regimen by a simple equation:

$$F = P - (C + E^1 + E^2) + S.$$

In this equation F is the flow of the river. This is determined primarily by the rainfall (P), subtracting, however, the amount of water which is cut off by sinking into the ground (C) and the amount which is evaporated directly (E^1) or indirectly through plants (E^2), and adding the amount of water which emerges again from the ground water through springs (S). Any condition which diminishes the values of C and E in-

[1]Reference 2.

creases the flow of rivers. Yet since in the long run *C* and *S* are very nearly balanced, it follows that the volume of water in the streams must vary largely with *P* and *E*. The regimen of a stream, then, reflects closely the climatic conditions; it is most irregular in the *w* or *s* climates and most regular in the *f* climates (see Appendix B). In the case of streams draining areas of considerable snowfall, however, the spring melting is commonly the season of high water. Lakes have the effect of regularizing the flow of water, regardless of the regime of rainfall.

10. **Ice.** The following classification of ice forms was suggested by Nordenskjöld.[1]

A. Highland Glaciers

- **I.** Ice forms and ice motion dependent on the character of the underlying terrain.
  - **1.** Glaciers in distinct catchment basins bordered by dominating ice-free ridges, outlets down-valley (valley glacier). Fig. 234.
  - **2.** Glacier occupying an isolated catchment basin on the top of a plateau or highland (plateau glacier).
  - **3.** Glacier resulting from the accumulation of several converging valley glaciers at the base of a mountain (piedmont glacier).
- **II.** Ice forms and ice motion independent or partially independent of the underlying terrain.
  - **4.** Glacier covering most of surface, although the general shape of the underlying terrain is visible in the ice contour (near icecap). Fig. 166.
  - **5.** Glacier covering the whole surface to such a depth that no sign of the underlying terrain is apparent in the ice contour (inland ice). Fig. 158.

B. Lowland Glaciers

- 6. Accumulation of glacial ice in a band along the base of a mountain; not fed, as is the piedmont glacier, by converging valley glaciers, but formed in place from snow accumulation (ice foot).
- **7.** Accumulation of glacial ice on the seacoast, extending out into the water so that in some cases its outer margin is floating, and formed in place from snow accumulation (shelf ice). Fig. 157.

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E · STATISTICS

Table I. Percentage of Land Area in the Eight Groups

	North America	South America	Africa	Europe	Asia	Australia New Zealand Philippines East Indies	Antarctica	World
I	10	8	34	(T)[1]	25	27	—	18
II	4	45	14	—	13	27	—	15
III	(T)	(T)	1	6	(T)	5	—	1
IV	14	2	(T)	38	7	7	—	7
V	12	30	46	19	10	27	—	21
VI	21	—	—	22	18	—	—	10
VII	23	—	—	4	6	—	100	16
VIII	16	15	5	11	21	7	—	12

Table II. Population (in Hundreds of Thousands) by Continents and Groups. Population Statistics from Various Sources, Estimated as of 1938. Percentages Are Given in Italics

	North America	South America	Africa	Europe	Asia	Australia New Zealand Philippines East Indies	World
I	5,900	3,800	27,100	100	44,100	100	81,100
	3	*4*	*17*	*(T)*	*4*	*(T)*	*4*
II	19,900	35,800	32,500	—	442,700	77,100	608,000
	11	*39*	*20*		*40*	*81*	*28*
III	3,800	3,100	9,300	48,300	12,500	1,300	78,300
	2	*3*	*6*	*9*	*1*	*2*	*4*
IV	106,700	2,300	1,800	327,600	395,400	6,900	840,700
	58	*3*	*1*	*62*	*36*	*7*	*39*
V	22,000	26,700	68,400	87,300	55,600	400	260 [illegible]0
	12	*29*	*42*	*17*	*5*	*(T)*	*12*
VI	2,100	—	—	20,100	12,800	—	35,000
	1			*4*	*1*		*1*
VII	(T)	—	—	700	300	—	1,000
				(T)	*(T)*		*(T)*
VIII	23,100	19,700	22,100	43,300	140,900	9,800	258,900
	13	*22*	*14*	*8*	*13*	*10*	*12*

[1]T indicates less than one half of one per cent.

TABLE III. CLIMATIC DATA FOR SELECTED STATIONS

T. = temperature in degrees Fahrenheit; Rf. = rainfall in inches.

	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR
1. T.	27.9	28.8	35.6	46.4	57.1	66.5	71.7	69.9	63.2	53.6	42.0	32.5	49.6
Rf.	3.6	3.4	3.6	3.3	3.2	2.9	3.5	3.6	3.1	3.1	3.3	3.4	40.0
2. T.	25.6	27.0	36.6	47.4	58.4	68.1	74.0	72.9	66.3	54.8	41.5	30.3	50.2
Rf.	2.0	2.1	2.6	2.8	3.6	3.3	3.4	3.0	3.1	2.6	2.4	2.1	33.0
3. T.	−23.1	−11.3	3.8	29.1	46.4	56.7	59.3	54.3	42.4	25.1	0.7	−13.1	22.5
Rf.	0.8	0.8	0.5	0.7	0.9	1.3	1.6	1.6	1.7	1.3	1.3	1.1	13.6
4. T.	29.9	31.6	38.9	47.4	56.7	67.2	72.2	70.9	62.4	50.5	39.2	31.6	49.9
Rf.	0.4	0.5	1.0	2.1	2.4	1.3	1.6	1.4	1.0	1.0	0.6	0.7	14.0
5. T.	5.5	10.5	23.4	40.5	51.0	57.2	61.1	59.2	50.2	41.1	24.7	14.3	36.5
Rf.	0.9	0.6	0.7	0.8	1.8	3.2	3.4	2.4	1.4	0.7	0.7	0.8	17.4
6. T.	18.5	18.7	23.5	30.9	40.1	46.6	49.8	47.3	41.0	33.8	26.4	20.7	33.1
Rf.	3.3	2.7	3.4	2.4	3.6	3.0	3.3	3.8	6.0	5.9	4.4	3.1	44.9
7. T.	57.0	60.1	64.9	70.7	73.9	72.3	69.8	69.6	67.8	64.9	61.2	56.8	65.7
Rf.	0.4	0.3	0.7	0.2	1.2	4.5	6.1	5.2	4.5	1.4	0.5	0.4	25.4
8. T.	57.9	61.7	67.8	73.0	79.0	81.9	82.2	82.6	78.1	71.4	63.5	57.4	71.4
Rf.	0.5	0.5	0.7	1.1	1.2	2.3	2.1	2.0	4.4	2.4	1.3	1.0	19.5
9. T.	13.0	14.7	25.4	41.1	55.1	64.7	69.3	67.0	58.7	46.7	32.7	19.1	42.3
Rf.	3.7	3.2	3.7	2.4	3.1	3.4	3.7	3.3	3.5	3.3	3.4	3.7	40.4
10. T.	54.2	57.3	62.8	68.8	75.4	80.6	82.4	82.2	79.2	71.0	61.6	55.6	69.2
Rf.	4.3	4.2	4.7	5.2	4.6	5.9	6.4	5.8	5.0	3.3	3.1	4.8	57.3
11. T.	30.6	30.5	38.0	48.5	59.4	68.5	73.5	72.1	66.4	55.8	44.1	34.3	51.8
Rf.	3.2	3.3	3.4	3.3	3.5	3.5	4.1	4.3	3.4	3.4	3.4	3.3	42.1
12. T.	50.4	54.4	60.2	66.9	74.6	84.2	89.6	88.0	81.7	70.0	58.6	51.6	69.2
Rf.	1.0	0.7	0.6	0.4	0.1	0.1	1.3	1.0	0.7	0.5	0.8	0.7	7.9
13. T.	16.0	18.6	31.5	46.8	58.0	68.5	75.3	72.8	63.8	49.8	33.6	21.8	46.4
Rf.	0.5	0.5	0.9	1.8	2.5	3.0	2.7	2.1	1.1	0.8	0.5	0.5	16.9
14. T.	−19.9	−13.0	−13.1	−1.7	21.7	35.3	40.9	38.5	32.1	16.3	0.3	−15.4	10.2
Rf.	0.1	0.4	0.2	0.3	0.3	0.3	0.9	0.9	0.5	0.7	0.3	0.4	5.3
15. T.	38.9	41.5	46.3	51.2	56.6	61.4	66.6	66.4	60.9	53.6	45.9	41.0	52.5
Rf.	6.5	5.5	4.8	3.0	2.3	1.6	0.6	0.6	1.9	3.2	6.5	6.9	43.5
16. T.	45.8	50.1	54.3	58.1	63.3	69.4	73.2	72.9	69.3	62.9	53.6	46.2	59.9
Rf.	3.7	3.0	2.6	1.5	0.8	0.1	0	0	0.4	0.9	1.9	3.0	17.9
17. T.	22.5	22.3	25.7	31.3	35.8	39.0	39.9	40.1	38.8	34.3	30.9	26.2	32.2
18. T.	31.6	33.7	44.2	55.8	66.2	75.0	79.2	77.3	70.1	58.3	45.4	35.6	56.0
Rf.	2.3	2.6	3.5	3.8	4.5	4.6	3.6	3.5	3.2	2.8	2.9	2.5	39.8
19. T.	12.1	15.2	29.0	45.6	58.6	67.4	72.3	69.4	60.6	48.1	32.1	19.8	44.2
Rf.	0.9	0.9	1.5	2.3	3.5	4.3	3.5	3.3	3.1	2.3	1.3	1.0	27.9
20. T.	54.0	54.9	56.5	58.3	60.5	63.5	66.8	68.4	66.9	63.2	59.1	55.6	60.6
Rf.	1.8	1.9	1.5	0.6	0.3	0.1	0.1	0.1	0.1	0.4	0.9	1.8	9.6
21. T.	49.4	51.4	52.8	54.3	55.5	57.2	57.3	57.8	59.9	58.9	55.5	50.6	55.0
Rf.	4.8	3.6	3.1	1.6	0.7	0.1	0	0	0.3	0.9	2.4	4.5	22.0
22. T.	31.7	34.1	36.5	41.3	46.6	51.3	54.8	55.5	51.7	45.8	38.2	35.4	43.6
Rf.	7.6	6.5	5.6	5.5	4.1	3.4	4.2	7.1	10.1	12.2	9.5	9.0	84.8
23. T.	71.0	72.1	71.0	68.5	65.3	63.1	62.2	64.4	68.1	70.3	70.3	70.1	68.0
Rf.	13.2	7.2	7.7	2.9	0.6	0.4	0.2	0.6	0.9	4.4	8.8	11.6	58.5
24. T.	73.6	72.5	68.7	61.3	55.0	49.6	48.9	51.1	55.0	59.9	65.8	70.9	61.0
Rf.	3.1	2.7	4.4	3.5	2.9	2.5	2.2	2.5	3.0	3.5	3.1	3.9	37.3

Climatic Data for Selected Stations (*continued*)

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
25. T. Rf.	73.8 4.2	72.5 4.2	68.5 3.5	62.1 1.8	55.8 1.0	49.6 0.3	50.4 0.3	51.6 0.5	58.6 0.9	63.3 2.4	68.4 4.0	72.3 4.6	62.2 27.7
26. T. Rf.	81.0 9.8	80.8 8.3	80.7 8.3	80.2 4.0	77.5 2.0	75.4 0.3	75.9 0.2	78.3 1.1	82.0 2.2	81.7 4.5	82.0 5.9	81.3 8.1	79.8 54.7
27. T. Rf.	69.4 0	69.4 0	67.6 0	64.8 0	62.6 0	61.2 0	60.4 0	60.3 0	61.2 0.1	63.0 0	65.3 0	67.5 0	64.4 0.1
28. T. Rf.	46.6 12.1	46.8 9.7	46.0 11.7	44.2 11.2	41.9 9.0	39.9 9.4	39.0 9.5	39.4 8.4	40.1 9.0	41.7 9.4	42.6 9.8	44.8 10.2	42.7 119.4
29. T. Rf.	72.7 0	74.3 0	73.6 0	70.2 0	66.0 0.1	62.6 0.2	61.2 0.3	61.0 0.4	61.3 0.4	63.0 0.2	65.7 0.1	70.0 0	66.8 1.7
30. T. Rf.	79.9 9.2	80.1 9.0	79.7 9.6	79.9 8.5	80.1 7.0	80.1 3.6	80.6 2.2	81.7 1.4	82.8 2.0	82.8 4.1	82.2 5.5	80.6 7.7	80.9 69.8
31. T. Rf.	75.2 2.7	75.4 1.5	76.3 1.8	77.8 1.8	79.1 3.6	78.1 7.9	77.9 8.8	77.8 9.6	78.3 7.4	78.2 6.6	77.5 7.0	76.3 4.7	77.3 63.4
32. T. Rf.	54.6 4.1	54.5 4.2	54.5 5.1	54.5 7.4	54.6 5.0	54.6 1.5	54.5 0.8	54.6 1.4	54.8 2.9	54.6 3.6	54.5 3.7	54.6 3.8	54.6 43.5
33. T. Rf.	58.8 0.6	57.6 0.4	54.5 0.3	47.9 0.6	41.2 0.6	35.4 0.5	35.1 0.7	38.3 0.4	43.5 0.2	48.8 0.4	53.1 0.5	56.3 0.9	47.5 6.1
34. T. Rf.	67.3 0	66.0 0.1	61.9 0.2	56.1 0.6	50.5 2.6	46.0 3.3	46.0 3.1	48.2 2.2	52.2 1.3	56.1 0.5	61.0 0.2	65.7 0.2	56.4 14.3
35. T. Rf.	61.9 2.4	60.4 3.0	57.9 5.5	53.1 9.4	49.6 15.2	45.5 17.0	45.7 16.1	46.4 13.2	48.0 8.7	52.0 5.2	55.0 5.0	59.0 4.1	52.9 104.8
36. T. Rf.	8.1 0.9	9.7 0.7	17.4 1.1	30.0 0.7	41.5 1.2	52.7 1.8	59.5 2.5	55.2 2.4	45.7 2.1	33.8 1.6	21.4 1.2	12.2 0.9	32.3 17.1
37. T. Rf.	19.2 0.5	22.8 0.4	32.7 0.4	47.8 0.7	63.5 0.7	72.5 0.8	76.1 0.5	73.8 0.5	62.6 0.5	49.5 0.5	36.0 0.5	26.6 0.6	48.6 6.6
38. T. Rf.	24.1 18.7	23.8 15.1	24.0 17.0	27.6 10.2	33.0 8.3	39.7 7.8	41.1 11.3	40.4 14.0	38.0 16.9	31.4 14.8	28.9 16.0	25.2 21.2	31.4 171.3
39. T. Rf.	26.2 1.3	30.6 1.1	41.0 1.6	52.2 1.7	62.2 2.4	68.9 3.5	72.9 2.7	72.0 2.0	63.5 1.5	52.9 1.7	39.7 1.9	30.9 1.6	51.1 23.0
40. T. Rf.	50.5 3.6	52.2 3.5	54.3 3.4	57.6 2.5	60.3 1.9	66.7 0.7	70.0 0.1	71.1 0.2	68.4 1.4	62.2 3.2	56.5 4.3	51.6 4.0	60.1 28.8
41. T. Rf.	12.6 1.3	15.6 1.2	24.3 1.4	38.1 1.3	53.2 1.8	60.1 2.6	64.4 3.2	60.4 3.1	49.8 2.2	38.6 2.1	27.0 1.7	17.6 1.6	38.5 23.5
42. T. Rf.	34.9 1.5	39.4 1.4	43.2 1.6	49.3 1.7	56.1 1.9	61.7 2.1	64.6 2.2	63.9 2.1	58.5 1.9	50.0 2.3	42.4 1.9	38.1 2.0	50.2 22.6
43. T. Rf.	29.8 3.8	29.8 3.3	31.1 2.7	36.3 2.4	42.8 1.9	48.6 1.9	51.6 1.9	50.5 2.0	45.5 3.5	39.2 3.4	33.8 3.7	30.0 3.5	39.1 34.0
44. T. Rf.	44.6 3.2	46.8 2.7	50.9 2.9	56.7 2.6	64.4 2.2	70.9 1.5	76.1 0.7	75.6 1.0	69.6 2.5	61.7 5.0	52.7 4.4	46.4 3.8	59.7 32.5
45. T. Rf.	30.6 1.0	32.9 0.8	39.7 1.1	49.3 1.1	60.4 1.2	68.0 1.9	72.1 1.4	71.1 1.3	63.9 1.4	55.0 1.5	43.7 1.5	35.8 1.1	51.9 15.3
46. T. Rf.	24.4 1.2	23.4 1.1	27.9 1.1	37.8 1.2	48.7 1.7	57.4 2.0	61.9 2.7	58.5 2.8	50.4 2.0	41.4 2.1	32.2 2.7	25.5 1.6	40.8 22.2
47. T. Rf.	44.7 5.9	44.8 5.1	45.1 4.4	48.1 3.7	52.4 3.2	55.6 3.5	58.9 3.9	59.2 4.8	56.4 4.5	51.7 5.8	47.5 5.4	45.4 6.5	50.8 56.7
48. T. Rf.	61.3 0.7	65.6 0.5	76.8 0.4	87.3 0.1	93.1 0.3	92.6 4.7	86.4 12.0	84.4 11.0	84.3 6.3	79.3 2.3	69.4 0.3	61.7 0.2	78.5 38.8

CLIMATIC DATA FOR SELECTED STATIONS (*continued*)

	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR
49. T.	−0.6	2.3	14.9	33.6	52.3	63.7	68.0	63.0	51.8	35.8	16.9	5.0	33.9
Rf.	0.7	0.5	0.5	0.6	1.3	1.6	2.0	1.8	1.1	1.2	1.0	0.9	13.2
50. T.	77.9	77.9	78.1	79.5	79.7	79.2	78.6	79.0	79.7	79.9	79.3	78.4	78.9
Rf.	13.0	12.8	7.8	5.1	4.0	3.7	2.6	1.7	2.9	4.5	5.5	8.5	72.1
51. T.	56.5	57.7	61.2	66.0	71.8	77.7	82.0	83.1	80.8	76.1	67.3	60.6	70.1
Rf.	7.3	5.7	3.9	2.2	0.8	0.1	0	0	0.3	2.1	5.3	7.5	35.2
52. T.	75.5	75.7	79.5	83.1	85.8	84.0	81.4	80.8	80.9	82.4	80.6	77.4	80.6
Rf.	0.1	0.1	0	0	0.7	19.9	24.2	14.5	10.6	1.9	0.4	0	72.4
53. T.	57.9	59.0	65.5	74.1	82.4	86.1	89.6	90.2	86.5	79.5	70.1	61.5	75.2
Rf.	2.7	1.9	0.9	0.5	0	0	0	0	0	0.1	1.4	2.9	10.4
54. T.	66.6	71.2	80.2	85.6	86.1	85.1	83.7	83.2	83.2	79.3	73.5	66.5	78.7
Rf.	0.4	1.0	1.4	2.2	5.6	11.9	12.7	13.4	10.0	4.9	0.6	0.2	64.3
55. T.	53.2	54.9	60.9	63.7	66.3	68.1	68.6	68.6	68.9	66.1	61.0	54.7	62.9
Rf.	0.7	2.3	10.6	31.3	50.8	103.6	107.4	81.5	49.4	16.8	2.3	0.3	457.0
56. T.	80.5	82.0	84.2	85.0	83.6	80.0	79.0	79.2	79.9	80.4	81.1	80.7	81.3
Rf.	0.8	0.8	1.7	3.7	11.4	27.8	25.3	12.5	9.2	12.9	6.7	1.9	114.7
57. T.	79.5	80.4	81.8	82.7	82.8	81.6	81.2	81.2	81.2	80.5	80.0	79.5	81.0
Rf.	3.2	1.9	4.3	9.7	10.9	7.3	4.4	3.2	4.8	13.4	11.8	5.1	80.0
58. T.	40.1	42.6	50.4	61.9	71.4	79.7	85.5	85.5	76.6	66.6	55.2	44.6	63.3
Rf.	1.8	1.9	3.8	6.0	6.5	9.5	7.1	3.8	2.8	3.2	1.9	1.1	49.4
59. T.	60.0	58.7	63.0	70.4	76.8	80.9	82.0	81.5	80.5	76.3	69.3	62.7	71.8
Rf.	1.3	1.6	2.7	5.3	11.6	15.9	13.8	14.1	9.8	4.9	1.8	1.1	83.9
60. T.	61.3	64.7	75.0	85.0	91.8	92.4	86.2	83.6	83.6	79.7	70.3	62.9	78.0
Rf.	0.4	0.3	0.3	0.2	0.6	2.6	8.3	7.3	3.2	0.3	0.1	0.3	23.9
61. T.	65.3	68.4	75.0	80.6	84.7	86.8	84.3	82.4	82.0	80.0	74.0	67.4	77.6
Rf.	0.6	0.4	0.3	0.1	0.1	0.6	2.8	1.7	0.6	0	0.1	0.2	7.5
62. T.	76.2	77.7	81.1	85.3	89.8	90.0	87.6	86.0	85.2	82.3	78.9	76.7	83.1
Rf.	1.1	0.3	0.3	0.6	1.8	2.0	3.8	4.5	4.8	11.1	13.6	5.3	49.2
63. T.	30.9	31.5	36.7	46.8	54.1	60.8	67.8	71.6	65.1	54.7	45.0	36.0	50.1
Rf.	2.7	2.6	3.5	3.8	4.7	5.0	5.3	7.0	8.5	6.6	3.2	2.4	55.3
64. T.	8.1	14.0	29.7	46.9	60.1	70.5	76.5	74.5	61.3	48.4	29.1	14.0	44.4
Rf.	0.2	0.3	0.7	1.1	2.2	3.4	5.8	5.3	3.3	1.5	0.9	0.2	24.9
65. T.	22.8	22.3	31.6	37.2	43.9	50.0	57.6	62.6	58.8	50.4	39.4	29.3	42.1
Rf.	1.3	1.0	2.2	2.9	3.7	3.7	3.8	4.3	5.5	3.8	3.3	2.3	37.8
66. T.	57.3	57.4	58.9	60.4	61.7	60.9	58.8	59.3	59.3	59.5	59.1	57.8	59.2
Rf.	5.6	2.1	3.4	5.6	6.8	12.8	11.9	7.8	8.1	11.0	9.0	8.7	92.8
67. T.	79.0	81.0	83.7	85.8	84.2	82.2	81.5	81.7	81.7	81.1	80.2	78.8	81.7
Rf.	0.9	0.1	0.3	1.7	8.3	12.6	11.1	11.0	13.3	11.1	3.7	3.1	77.2
68. T.	79.8	80.1	81.1	82.3	82.6	81.7	81.8	81.8	81.7	81.5	80.8	80.1	81.3
Rf.	18.4	9.6	8.0	4.1	5.9	7.3	6.5	8.1	9.4	10.0	14.7	17.7	119.7
69. T.	37.4	38.8	44.4	54.5	61.9	68.9	75.6	77.7	71.4	60.4	50.5	41.4	56.9
Rf.	2.2	2.8	4.4	4.9	5.7	6.5	5.3	5.7	8.7	7.4	4.2	2.1	59.9
70. T.	−2.9	2.1	12.9	30.2	46.6	59.0	64.0	59.2	48.4	31.8	12.7	1.6	30.5
Rf.	1.1	0.8	0.8	0.7	1.5	2.7	3.0	2.3	1.4	2.4	1.4	1.9	20.0
71. T.	−58.2	−48.1	−23.8	9.5	36.3	56.1	59.9	51.6	36.1	5.7	−34.1	−51.3	3.3
Rf.	0.2	0.1	0.1	0.2	0.3	0.9	1.1	1.0	0.5	0.3	0.3	0.2	5.2
72. T.	−45.9	−33.2	−9.2	16.7	41.4	59.5	66.4	58.8	42.6	16.7	−20.0	−40.4	12.8
Rf.	0.2	0.2	0.1	0.2	0.5	1.1	1.3	1.7	0.9	0.5	0.4	0.3	7.4

CLIMATIC DATA FOR SELECTED STATIONS (*continued*)

	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR
73. T.	37.8	39.4	46.0	56.1	65.5	73.4	80.4	80.2	73.0	63.5	52.0	42.1	59.1
Rf.	2.0	2.3	3.5	3.7	3.5	7.2	6.0	5.7	4.4	3.2	2.1	1.4	45.0
74. T.	49.3	50.4	52.5	55.8	61.0	67.9	73.4	74.7	70.3	63.7	56.8	51.8	60.6
Rf.	4.0	2.6	3.3	2.0	1.7	0.7	0.1	0.1	1.1	3.4	4.1	3.9	27.0
75. T.	71.5	70.2	68.9	66.0	61.2	57.4	57.2	61.2	67.6	72.4	72.5	71.8	66.5
Rf.	5.9	4.0	3.1	0.6	0.3	0	0	0	0.1	0.9	3.3	5.2	23.4
76. T.	54.1	56.8	62.4	70.2	76.8	81.9	83.5	82.6	78.1	71.4	65.1	57.9	70.1
Rf.	0.3	0.2	0.2	0.1	0	0	0	0	0	0	0.2	0.2	1.2
77. T.	69.9	70.3	68.1	63.2	58.9	55.7	54.7	55.6	57.9	61.2	64.4	67.9	62.3
Rf.	0.7	0.6	0.9	1.9	3.8	4.5	3.6	3.4	2.3	1.6	1.1	0.8	25.2
78. T.	71.1	71.1	71.3	70.3	69.8	69.4	68.6	68.6	69.4	70.1	70.1	70.2	70.0
Rf.	2.6	3.6	5.8	9.7	8.5	5.1	2.9	3.1	3.1	3.5	5.0	5.1	58.0
79. T.	81.3	82.3	82.4	82.4	81.5	80.3	78.6	77.9	79.1	80.1	81.2	81.4	80.7
Rf.	0.4	0.3	1.2	4.1	11.5	20.0	35.6	36.6	28.5	12.6	5.1	1.4	157.3
80. T.	66.5	65.4	63.3	59.8	54.4	50.7	50.5	54.3	59.4	62.7	63.5	65.1	59.6
Rf.	6.2	5.2	4.4	1.7	0.8	0.1	0.3	0.5	1.0	2.6	5.0	5.4	33.2
81. T.	72.5	75.2	81.0	81.0	92.5	93.4	89.6	87.8	89.2	88.9	82.0	74.7	84.0
Rf.	0	0	0	0	0.1	0.3	1.8	2.6	0.7	0.2	0	0	5.7
82. T.	75.6	73.9	69.5	62.9	54.7	48.9	49.3	54.1	61.3	66.9	70.7	75.0	63.6
Rf.	2.8	3.1	3.0	1.3	0.9	0.3	0.4	0.4	0.7	1.0	1.7	2.4	18.0
83. T.	80.9	82.2	83.3	82.5	81.8	79.3	78.0	77.7	78.4	79.5	81.4	81.5	80.5
Rf.	1.1	2.1	3.7	5.7	10.5	18.6	10.7	2.8	5.3	7.8	2.6	0.8	71.7
84. T.	72.1	73.3	71.1	66.0	58.5	53.0	53.4	54.0	58.2	62.9	65.8	70.2	63.2
Rf.	0.2	0.3	0.4	0.6	1.0	1.1	0.8	0.9	0.6	0.4	0.2	0.2	6.7
85. T.	69.4	69.7	68.0	65.1	61.6	59.3	57.9	58.4	59.8	61.8	64.5	67.6	63.6
Rf.	1.2	1.3	1.8	2.0	2.4	1.7	1.9	2.1	2.2	2.1	2.1	1.7	22.5
86. T.	73.6	73.9	73.6	72.3	72.1	70.9	70.2	70.7	71.1	70.7	72.3	73.0	72.0
Rf.	1.6	2.7	5.9	9.1	8.1	4.5	2.6	3.3	7.6	8.9	5.9	2.0	62.2
87. T.	73.9	74.1	69.8	63.9	57.9	53.5	51.7	54.0	57.1	61.9	66.9	71.1	63.0
Rf.	0.7	0.6	1.0	1.7	2.8	3.1	2.6	2.5	2.0	1.7	1.2	1.0	20.9
88. T.	77.2	76.5	74.3	70.3	64.5	60.2	58.5	60.4	65.4	69.8	73.6	76.4	68.9
Rf.	6.3	6.2	5.6	3.6	2.8	2.6	2.3	2.1	2.0	2.6	3.7	4.8	44.6
89. T.	83.8	83.4	84.0	84.1	81.8	78.9	77.4	79.4	82.6	85.3	85.8	85.1	82.6
Rf.	15.9	12.9	10.1	4.1	0.7	0.1	0.1	0.1	0.5	2.2	4.8	10.3	61.8
90. T.	70.3	70.9	69.2	65.8	60.6	55.8	54.3	56.1	59.2	62.6	65.8	68.7	59.9
Rf.	0.7	0.5	0.9	1.3	1.2	1.1	0.9	0.8	0.8	0.7	0.7	0.4	10.0
91. T.	67.5	67.6	64.6	59.4	54.1	50.4	48.7	51.1	54.1	57.7	61.3	64.9	58.4
Rf.	1.8	1.8	2.1	2.2	2.1	2.0	1.8	1.7	2.4	2.6	2.2	2.2	24.9
92. T.	83.3	82.0	76.6	68.1	59.7	54.4	52.6	58.2	65.5	73.3	79.0	82.3	68.6
Rf.	1.8	1.7	1.2	0.7	0.7	0.6	0.4	0.4	0.4	0.7	1.0	1.6	11.2
93. T.	71.7	71.3	69.3	64.7	58.8	54.6	52.7	55.0	59.2	63.5	67.1	70.1	63.1
Rf.	3.7	4.2	4.8	5.6	5.1	4.8	4.8	3.0	2.9	3.2	2.8	2.9	47.8
94. T.	21.7	9.3	−7.4	−24.0	−27.0	−29.4	−33.7	−34.2	−29.4	−14.1	8.6	23.7	−11.3

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CLIMATIC STATIONS FOR WHICH DATA ARE GIVEN ON PAGES 568–571

The number in parentheses refers to the source of the data; the letter symbols are those of the Köppen classification (see definitions in Appendix B, sect. 30).

North America

1. Boston, U.S.A. . . . . . (2) *Cfa*
2. Chicago, U.S.A. . . . . (1) *Dfa*
3. Dawson, Canada . . . . (1) *Dfc*
4. Denver, U.S.A. . . . . (1) *BSkw*
5. Edmonton, Canada . . (1) *Dfb*
6. Ivigtut, Greenland . . (1) *ET*
7. León, Mexico . . . . . (1) *BShw*
8. Monterrey, Mexico . . (1) *BSh*
9. Montreal, Canada . . . . (1) *Dfb*
10. New Orleans, U.S.A. . (2) *Cfa*
11. New York, U.S.A. . . . (1) *Cfa*
12. Phoenix, U.S.A. . . . . (1) *BWh*
13. Pierre, U.S.A. . . . . . (2) *BSkw*
14. Point Barrow, Alaska . (2) *ET*
15. Portland (Oregon), U.S.A. . . . . (1) *Csb*
16. Sacramento, U.S.A. . . (2) *Csa*
17. Sagdlit, Greenland . . (3) *ET*
18. St. Louis, U.S.A. . . . . (1) *Cfa*
19. St. Paul, U.S.A. . . . . (1) *Dfa*
20. San Diego, U.S.A. . . (1) *BSksn*
21. San Francisco, U.S.A. . (1) *Csbt'n*
22. Sitka, Alaska . . . . . (1) *Cfbs'*

South America

23. Belo Horizonte, Brazil . (4) *Cwa*
24. Buenos Aires, Argentina (1) *Cfa*
25. Córdoba, Argentina . . (1) *Cwa*
26. Cuiabá, Brazil . . . . . (1) *Awi*
27. Iquique, Chile . . . . . (1) *BWh (k)*
28. Islote de los Evangelistas, Chile . . . . . (1) *ET*
29. Lima, Peru . . . . . . (5) *BWhsn*
30. Manaus, Brazil . . . . . (5) *Ami*
31. Port-of-Spain, Trinidad . (1) *Amwi*

32. Quito, Ecuador . . . (5) *Cfbi*
33. Santa Cruz, Argentina . (1) *BWk'*
34. Santiago, Chile . . . (1) *Csb*
35. Valdivia, Chile . . . (5) *Cfbs*

Europe

36. Arkhangelsk, U.S.S.R. . (1) *Dfc*
37. Astrakhan, U.S.S.R. . . (1) *BSk*
38. Ben Nevis, Great Britain (6) *ET*
39. București, Romania . . (1) *Dfa*
40. Lisboa, Portugal . . . (1) *Csb*
41. Moskva, U.S.S.R. . . . (1) *Dfb*
42. Paris, France . . . . (1) *Cfb*
43. Reykjavik, Iceland . . (5) *Cfc*
44. Roma, Italy . . . . . (1) *Cs'a*
45. Sulina, Romania . . . (1) *Cfa*
46. Uppsala, Sweden . . . (1) *Dfb*
47. Valentia, Ireland . . . (1) *Cfb*

Asia

48. Allahabad, India . . . (1) *Cwg*
49. Barnaul, U.S.S.R. . . . (7) *Dfb*
50. Batavia, Java . . . . (1) *Amwi*
51. Beirut, Syria . . . . (1) *Csa*
52. Bombay, India . . . . (1) *Awg*
53. Bushire, Iran . . . . (1) *BShs*
54. Calcutta, India . . . . (1) *Awg*
55. Cherrapunji, India . . (1) *Cwb*
56. Cochin, India . . . . (1) *Amgi*
57. Colombo, Ceylon . . . (1) *Amw''i*
58. Hankow, China . . . (8) *Cfa*
59. Hong Kong, China . . (1) *Cwa*
60. Jaipur, India . . . . (1) *BShw*
61. Karachi, Pakistan . . (6–1) *BWhw*
62. Madras, India . . . . (1) *Aw'*
63. Miyako, Japan . . . . (1) *Cfb (a)*
64. Mukden, Manchuria . . (1) *Dwa*
65. Nemuro, Japan . . . (1) *Dfb*
66. Nuwara Eliya, Ceylon . (1) *Cfbgi*
67. Saïgon, French Indo-China . . . . . . (1) *Awgi*
68. Sandakan, British North Borneo . . . . . (1) *Afsi*
69. Tokyo, Japan . . . . (1) *Cfa*
70. Tomsk, U.S.S.R. . . (1–6) *Dfc*
71. Verkhoyansk, U.S.S.R. . (7) *Dwd*
72. Yakutsk, U.S.S.R. . . . (7) *Dwd*
73. Zi-ka-wei (Shanghai), China . . . . . . (1) *Cfa*

Africa

74. Algiers, Algeria . . . (1) *Csa*
75. Bulawayo, Rhodesia . . (1) *BShw*
76. Cairo, Egypt . . . . (9) *BWhs*
77. Cape Town, South Africa . . . . . . (1) *Csb*
78. Entebbe, Uganda . . . (1) *Afw''i*
79. Freetown, Sierra Leone . (1) *Amgi*
80. Johannesburg, South Africa . . . . . . (1) *Cwb*
81. Khartoum, Anglo-Egyptian Sudan . . (1) *BWhw*
82. Kimberley, South Africa (1) *BSkw*
83. Lagos, Nigeria . . . . (1) *Aw''gi*
84. O'Okiep, South Africa . (1) *BWks*
85. Port Elizabeth, South Africa . . . . . . (1) *Cfb*
86. Yaunde, Cameroon . . (6) *Amw''i*

Australia

87. Adelaide . . . . . . (1) *Csa*
88. Brisbane . . . . . . (1) *Cfa*
89. Darwin . . . . . . (1) *Awgi*
90. Eucla . . . . (5) *BSk*
91. Melbourne . . . . . (5) *Cfb*
92. Stuart . . . . (1) *BWhw*
93. Sydney . . . . . . (1) *Cfa*

Antarctica

94. Framheim Little America . . . . (3) *EF*

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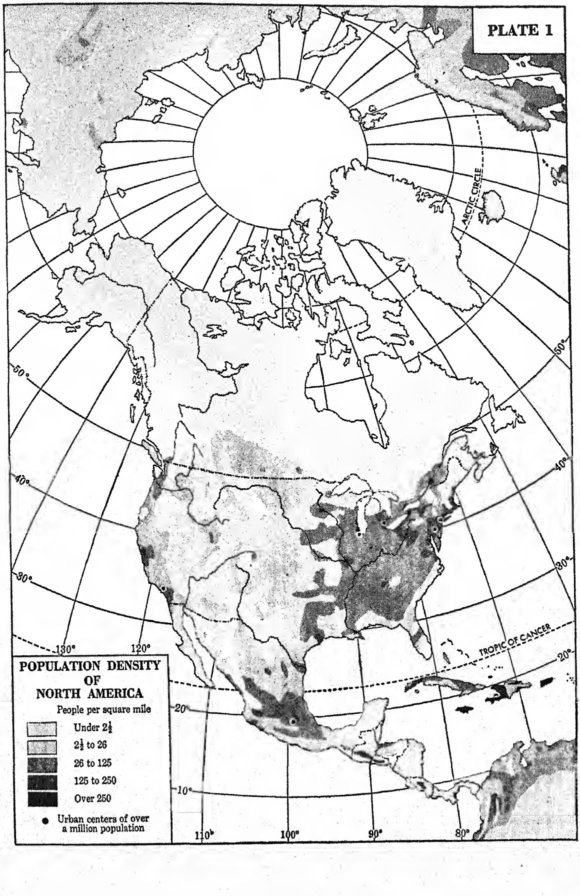


PLATE 1
ARCTIC CIRCLE
TROPIC OF CANCER
50°
40°
30°
20°
10°
130°
120°
110°
100°
90°
80°
POPULATION DENSITY
OF
NORTH AMERICA
People per square mile
Under 2½
2½ to 26
26 to 125
125 to 250
Over 250
Urban centers of over a million population


PLATE 2
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
POPULATION DENSITY OF SOUTH AMERICA
People per square mile
Under 2½
2½ to 26
26 to 125
125 to 250
Over 250
Urban centers of over a million population
70°
60°
50°
40°
30°
20°
10°
0°
100°
90°
80°

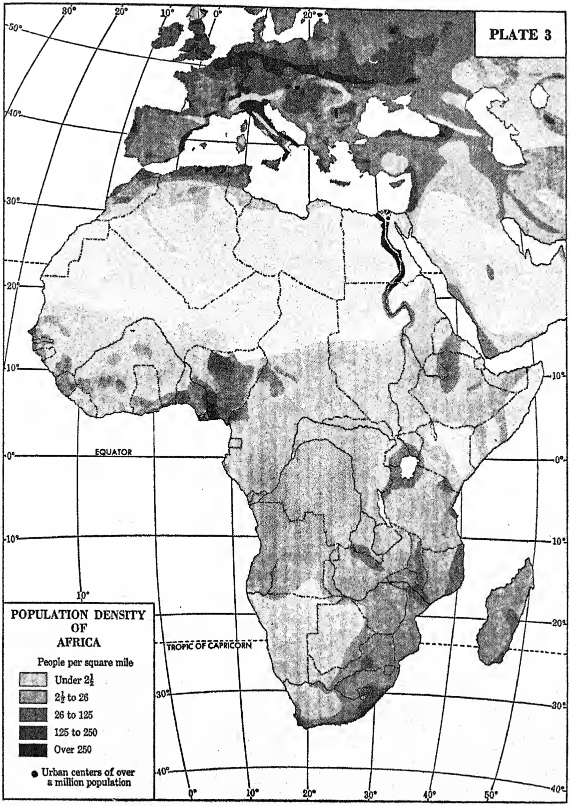


PLATE 3
POPULATION DENSITY
OF
AFRICA
People per square mile
Under 2½
2½ to 26
26 to 125
125 to 250
Over 250
● Urban centers of over a million population
EQUATOR
TROPIC OF CAPRICORN
50°
40°
30°
20°
10°
0°
10°
20°
30°
40°

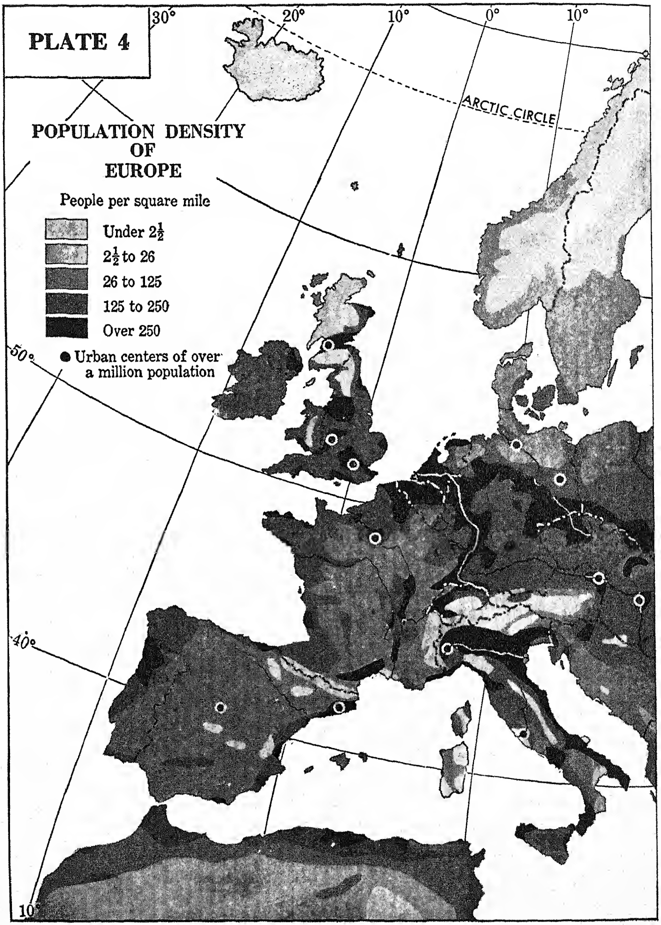
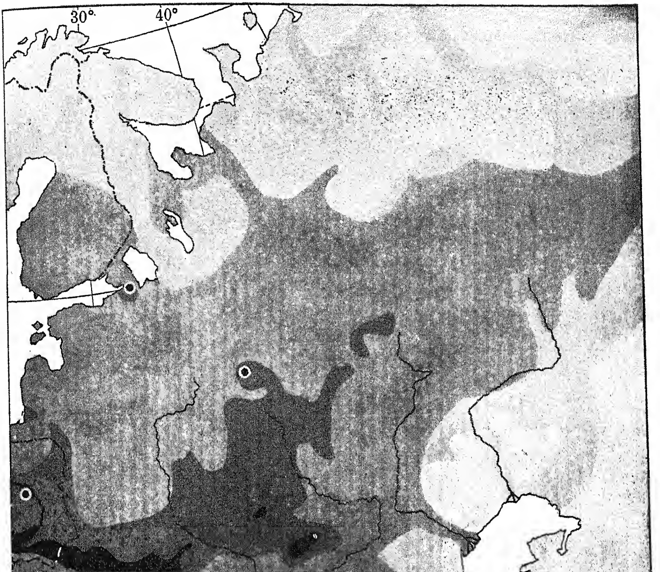


PLATE 4
POPULATION DENSITY
OF
EUROPE
People per square mile
Under 2½
2½ to 26
26 to 125
125 to 250
Over 250
Urban centers of over a million population
ARCTIC CIRCLE
30°
20°
10°
0°
10°
50°
40°
10°


30°
40°
30°

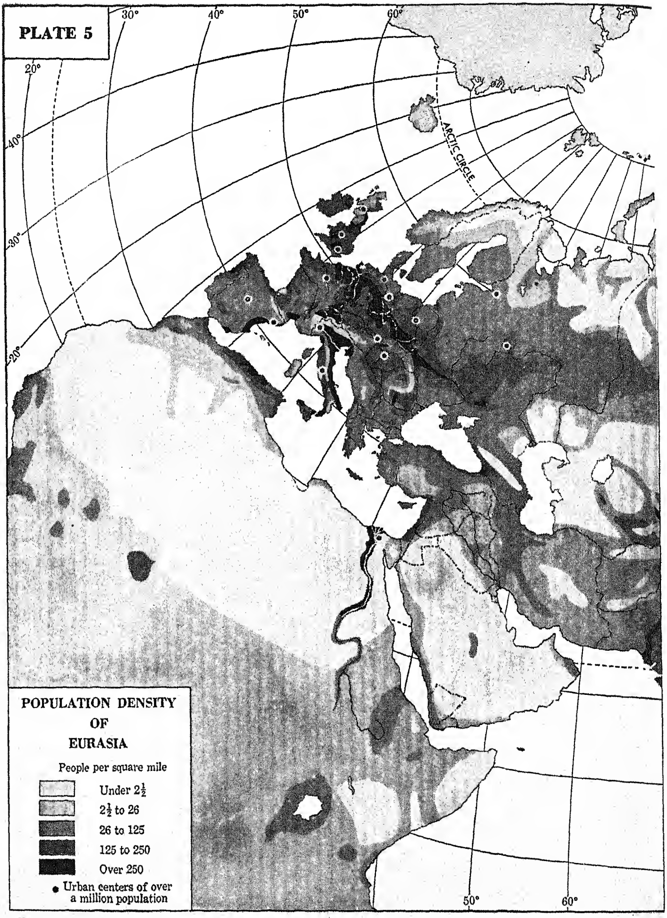
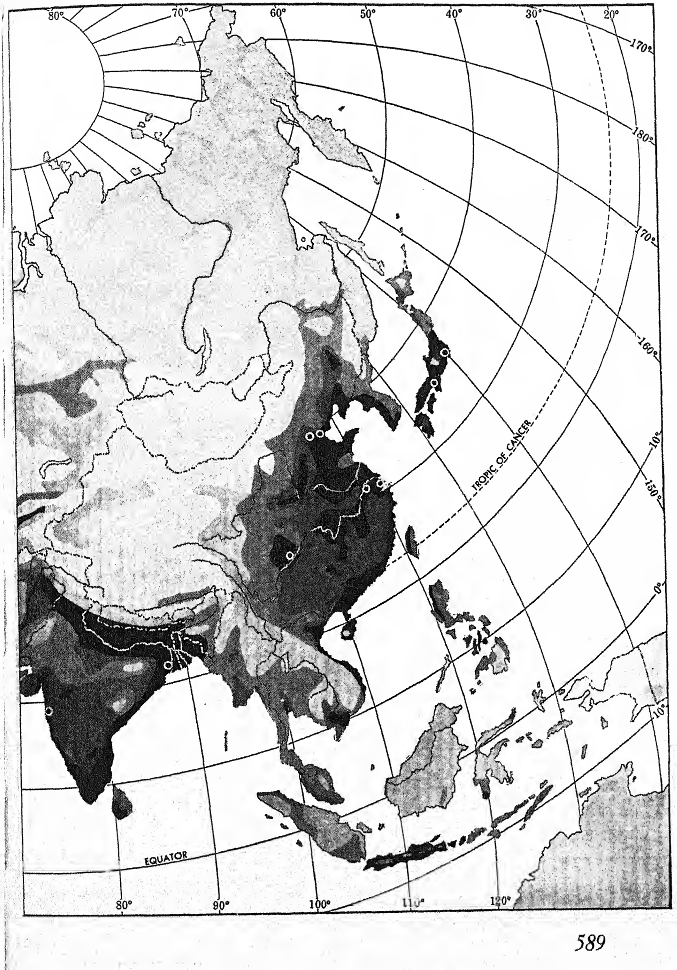


PLATE 5
POPULATION DENSITY
OF
EURASIA
People per square mile
Under 2½
2½ to 26
26 to 125
125 to 250
Over 250
Urban centers of over a million population
ARCTIC CIRCLE
20°
30°
40°
50°
60°


80°
70°
60°
50°
40°
30°
20°
170°
180°
170°
160°
10°
150°
0°
10°
TROPIC OF CANCER
EQUATOR
80°
90°
100°
110°
120°

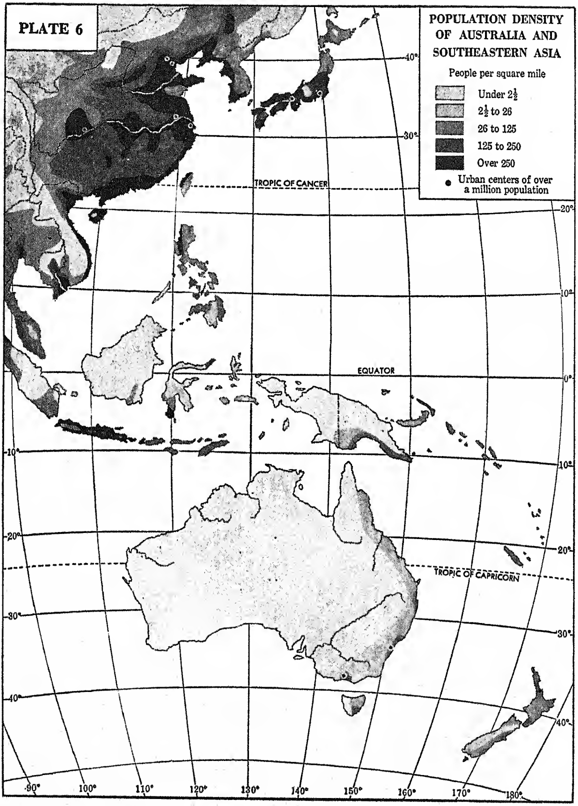


PLATE 6
POPULATION DENSITY OF AUSTRALIA AND SOUTHEASTERN ASIA
People per square mile
Under 2½
2½ to 26
26 to 125
125 to 250
Over 250
Urban centers of over a million population
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
40°
30°
20°
10°
0°
10°
20°
30°
40°
90°
100°
110°
120°
130°
140°
150°
160°
170°
180°

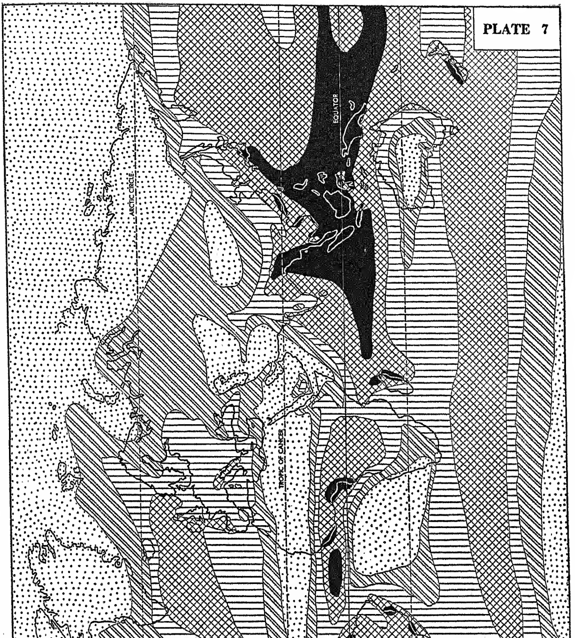


PLATE 7
ARCTIC CIRCLE
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
AVERAGE ANNUAL RAINFALL
Under 10 inches
10 – 20 inches
20 – 40 inches
40 – 80 inches
Over 80 inches
"after Gerhard Schott"

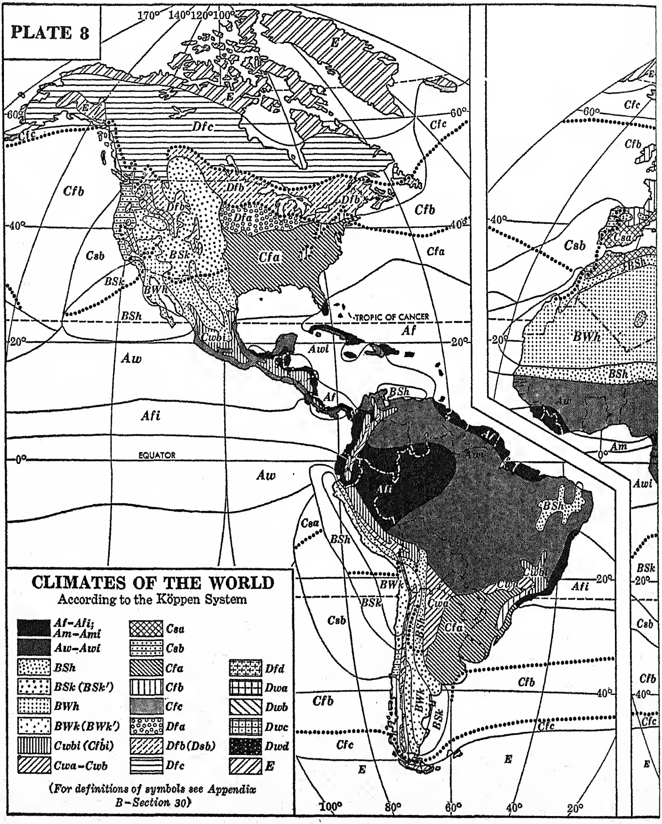
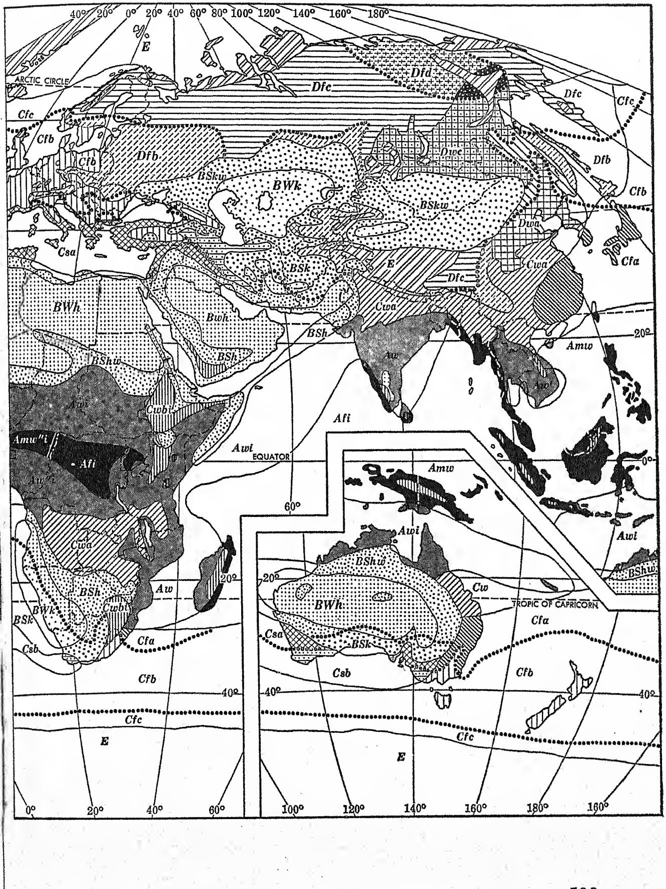


PLATE 8
CLIMATES OF THE WORLD
According to the Köppen System
Af–Afi; Am–Ami
Aw–Awi
BSh
BSk (BSk')
BWh
BWk (BWk')
Cwbi (Cfbi)
Cwa–Cwb
Csa
Csb
Cfa
Cfb
Cfc
Dfa
Dfb (Dsb)
Dfc
Dfd
Dwa
Dwb
Dwc
Dwd
E
(For definitions of symbols see Appendix B–Section 30)
TROPIC OF CANCER
EQUATOR



40°
20°
0°
20°
40°
60°
80°
100°
120°
140°
160°
180°
E
ARCTIC CIRCLE
Dfc
Dfd
Cfc
Cfb
Cfb
Dfb
Dwc
Dfb
Cfb
BSkw
BWk
BSkw
Dwa
Csa
BSk
E
Cwa
Cfa
Dfc
BWh
Bwh
Cwa
BSh
20°
Amw
BSh
BShw
Aw
Aw'
Awi
Cwbi
Afi
Amw"i
Afi
Awi
EQUATOR
0°
Aw"i
Amw
60°
Awi
Awi
Cwa
BShw
BShw
20°
20°
Aw
Cw
BSh
BWh
Cwbi
TROPIC OF CAPRICORN
BWk
Cfa
BSk
Csa
Cfa
BSk
Csb
Csb
Cfb
Cfb
40°
40°
40°
Cfc
Cfc
E
E
0°
20°
40°
60°
100°
120°
140°
160°
180°
160°

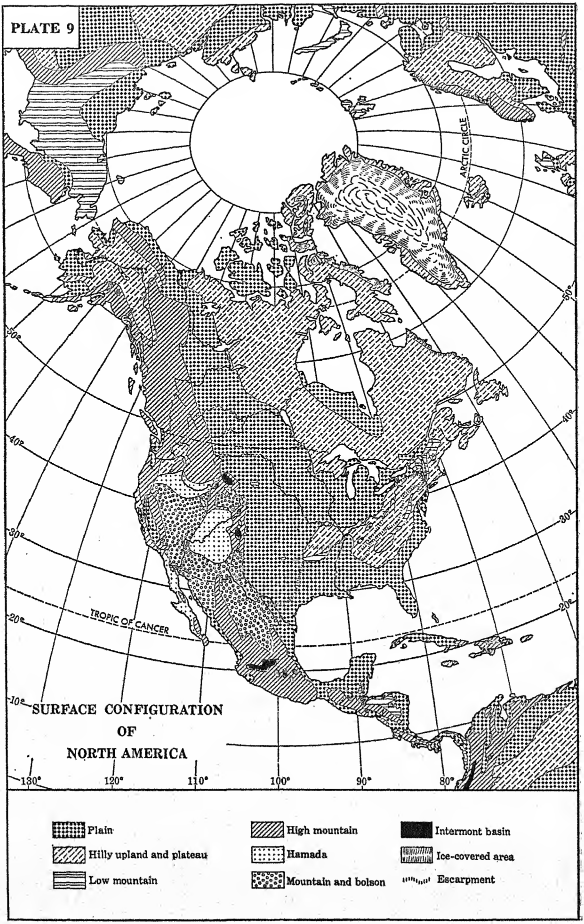


PLATE 9
SURFACE CONFIGURATION
OF
NORTH AMERICA
ARCTIC CIRCLE
TROPIC OF CANCER
50°
40°
30°
20°
10°
130°
120°
110°
100°
90°
80°
Plain
Hilly upland and plateau
Low mountain
High mountain
Hamada
Mountain and bolson
Intermont basin
Ice-covered area
Escarpment

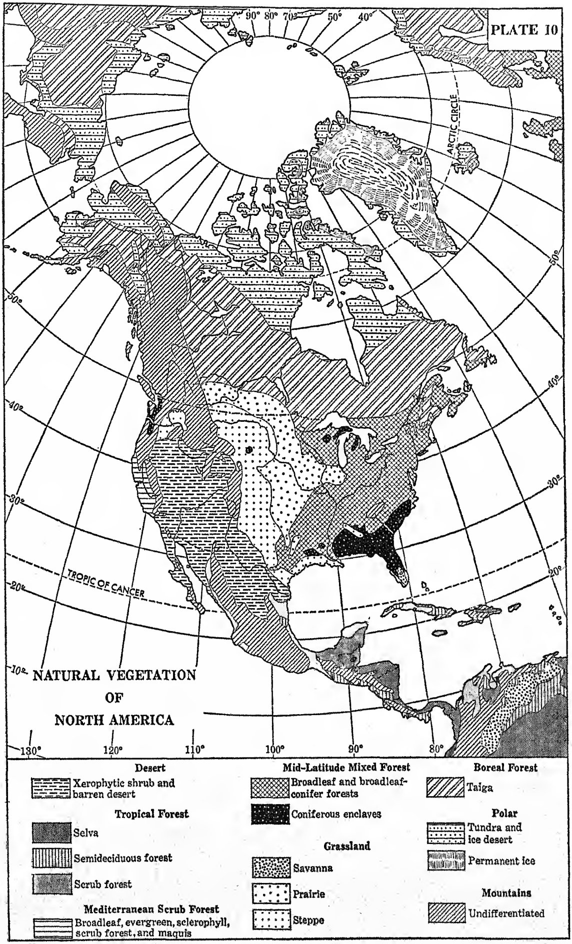


PLATE 10
NATURAL VEGETATION
OF
NORTH AMERICA
ARCTIC CIRCLE
TROPIC OF CANCER
90° 80° 70° 50° 40°
50° 40° 30° 20° 10°
130° 120° 110° 100° 90° 80°
Desert
Xerophytic shrub and barren desert
Tropical Forest
Selva
Semideciduous forest
Scrub forest
Mediterranean Scrub Forest
Broadleaf, evergreen, sclerophyll, scrub forest, and maquis
Mid-Latitude Mixed Forest
Broadleaf and broadleaf-conifer forests
Coniferous enclaves
Grassland
Savanna
Prairie
Steppe
Boreal Forest
Taiga
Polar
Tundra and ice desert
Permanent ice
Mountains
Undifferentiated


PLATE 11
SURFACE CONFIGURATION
OF
SOUTH AMERICA
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
70°
60°
50°
40°
30°
20°
10°
0°
10°
20°
30°
40°
50°
130°
120°
110°
100°
90°
80°
70°
60°
50°
40°
30°
20°
Plain
Hilly upland and plateau
Low mountain
High mountain
Hamada
Mountain and bolson
Intermont basin
Ice-covered area
Escarpment


PLATE 12
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
NATURAL VEGETATION
OF
SOUTH AMERICA
Desert
Xerophytic shrub and barren desert
Tropical Forest
Selva
Semideciduous forest
Scrub forest
Mediterranean Scrub Forest
Broadleaf, evergreen, sclerophyll, scrub forest, and maquis
Mid-Latitude Mixed Forest
Broadleaf and broadleaf conifer forests
Coniferous enclaves
Grassland
Savanna
Prairie
Steppe
Mountains
Undifferentiated

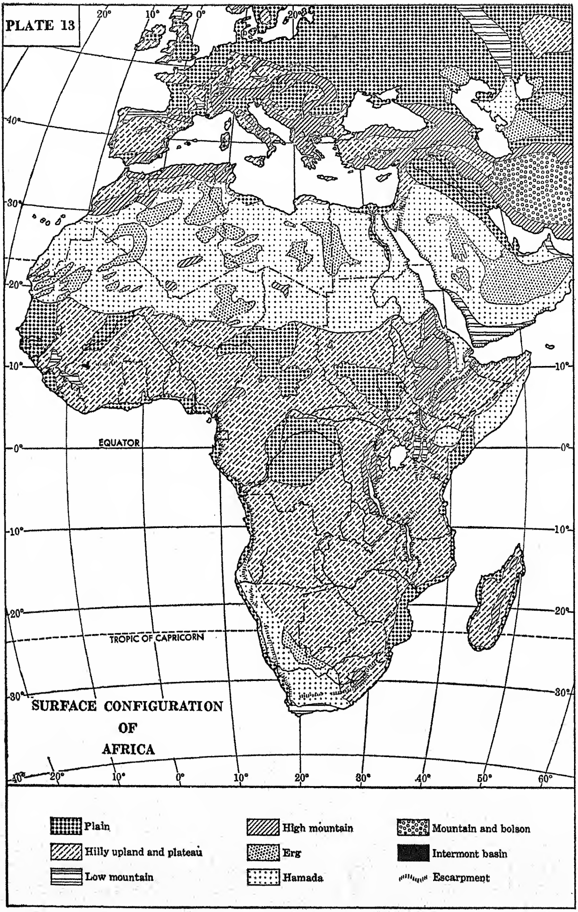


PLATE 13
SURFACE CONFIGURATION OF AFRICA
EQUATOR
TROPIC OF CAPRICORN
Plain
Hilly upland and plateau
Low mountain
High mountain
Erg
Hamada
Mountain and bolson
Intermont basin
Escarpment

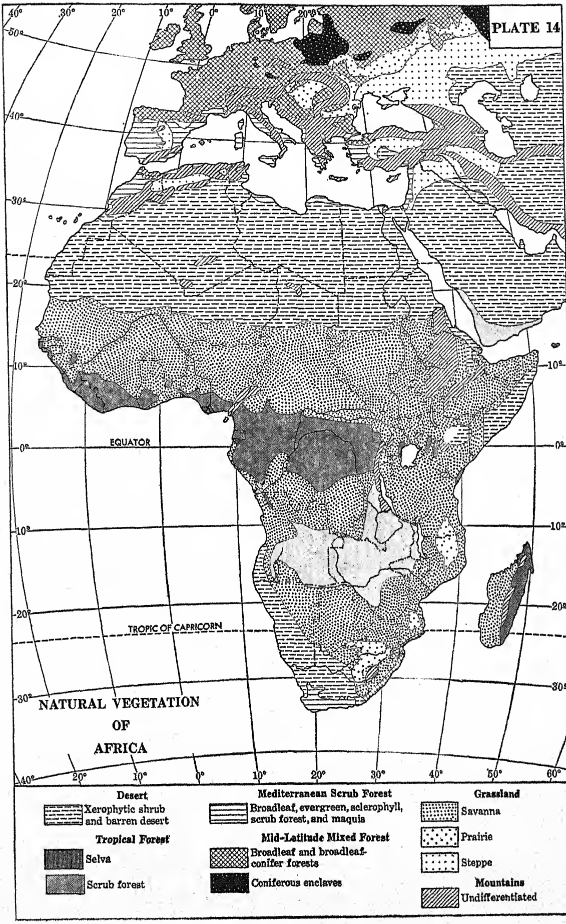


PLATE 14
NATURAL VEGETATION OF AFRICA
EQUATOR
TROPIC OF CAPRICORN
Desert
Xerophytic shrub and barren desert
Tropical Forest
Selva
Scrub forest
Mediterranean Scrub Forest
Broadleaf, evergreen, sclerophyll, scrub forest, and maquis
Mid-Latitude Mixed Forest
Broadleaf and broadleaf-conifer forests
Coniferous enclaves
Grassland
Savanna
Prairie
Steppe
Mountains
Undifferentiated

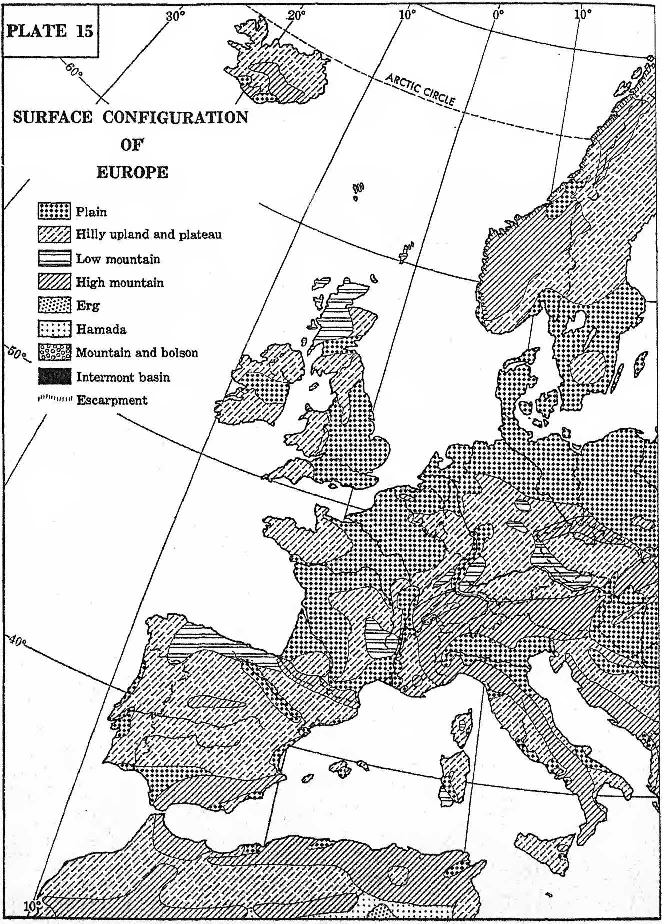
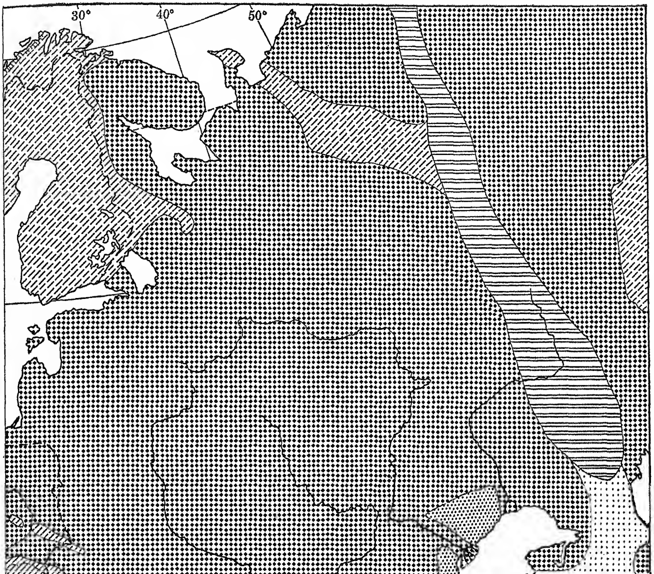


PLATE 15
SURFACE CONFIGURATION
OF
EUROPE
Plain
Hilly upland and plateau
Low mountain
High mountain
Erg
Hamada
Mountain and bolson
Intermont basin
Escarpment
ARCTIC CIRCLE
30°
20°
10°
0°
10°
60°
50°
40°
10°



30°
40°
50°
30°

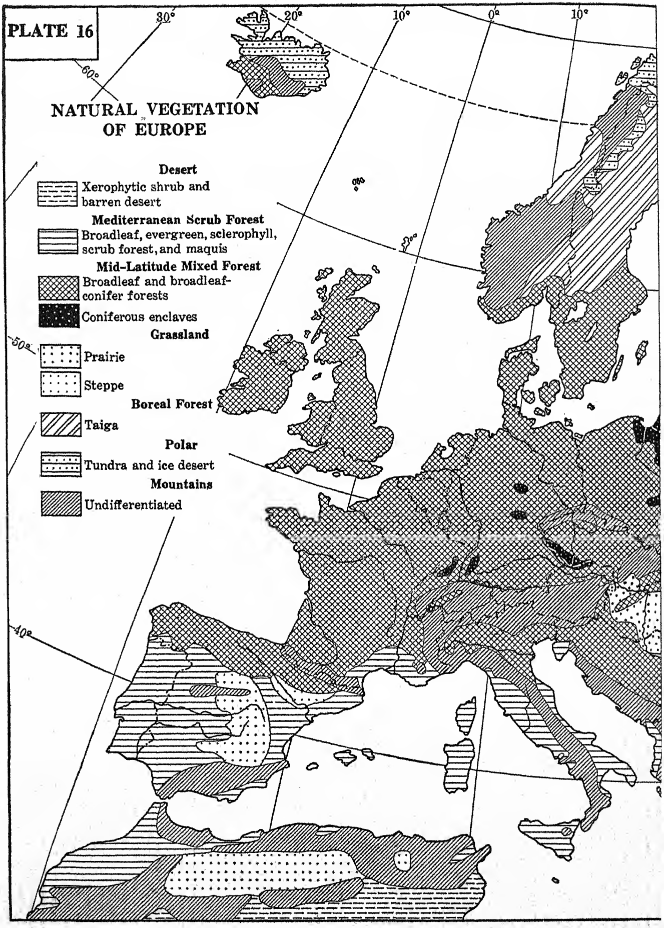
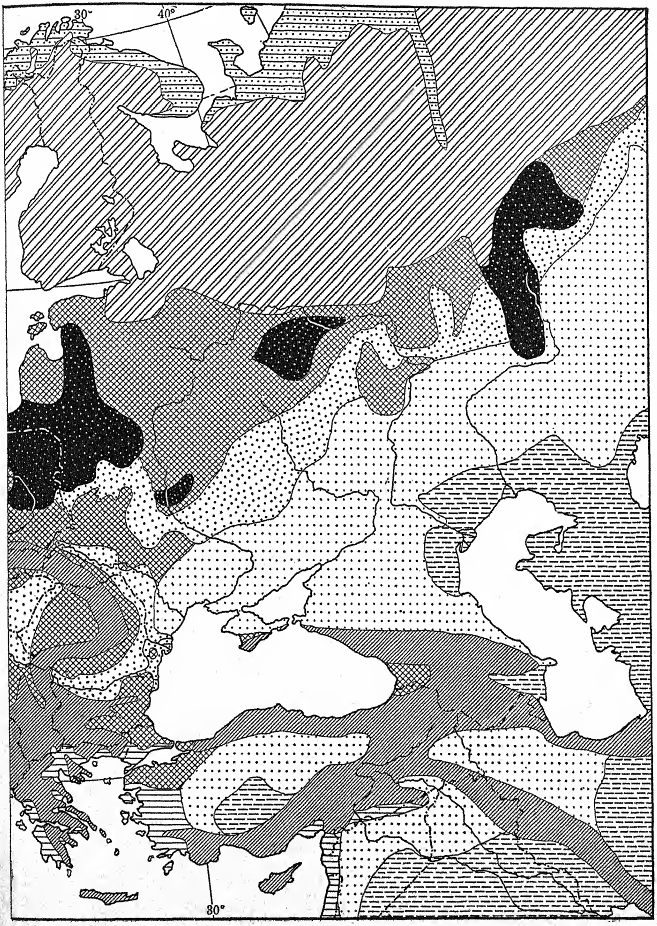


PLATE 16
NATURAL VEGETATION OF EUROPE
Desert
Xerophytic shrub and barren desert
Mediterranean Scrub Forest
Broadleaf, evergreen, sclerophyll, scrub forest, and maquis
Mid-Latitude Mixed Forest
Broadleaf and broadleaf-conifer forests
Coniferous enclaves
Grassland
Prairie
Steppe
Boreal Forest
Taiga
Polar
Tundra and ice desert
Mountains
Undifferentiated
30°
20°
10°
0°
10°
60°
50°
40°


30°
40°
30°

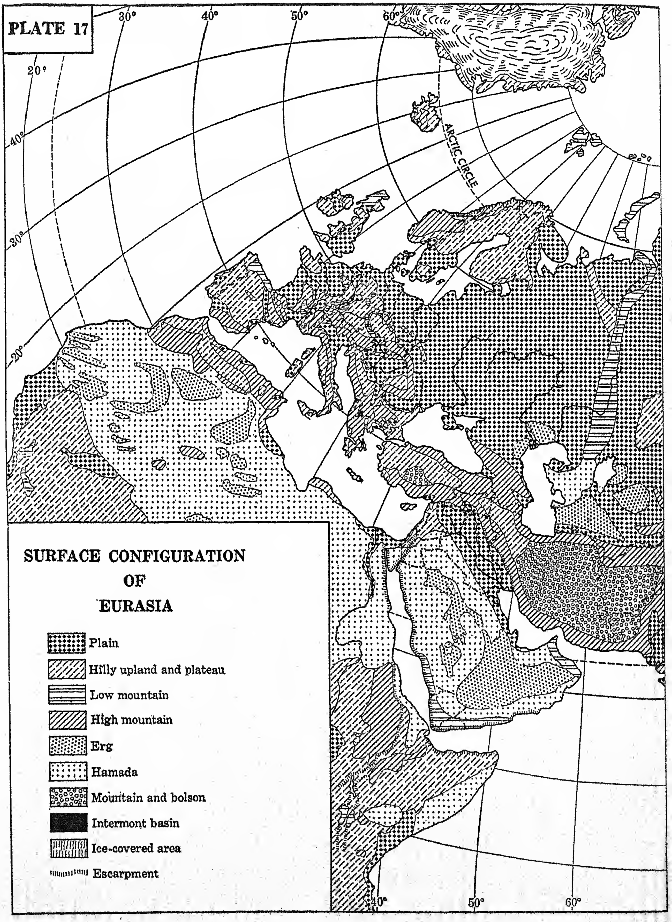
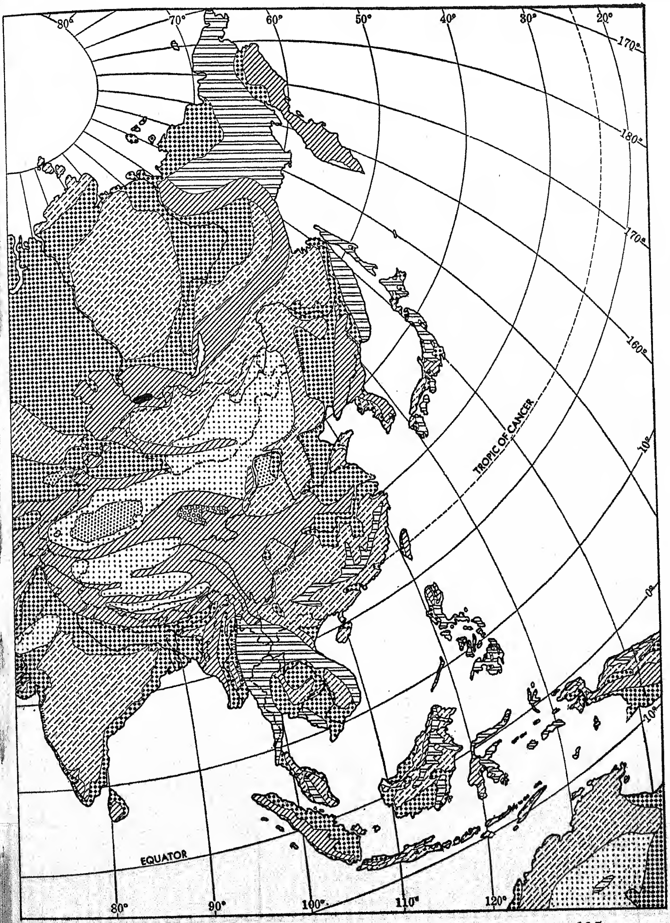


PLATE 17
SURFACE CONFIGURATION OF EURASIA
Plain
Hilly upland and plateau
Low mountain
High mountain
Erg
Hamada
Mountain and bolson
Intermont basin
Ice-covered area
Escarpment
ARCTIC CIRCLE
20°
30°
40°
50°
60°


80°
70°
60°
50°
40°
30°
20°
170°
180°
170°
160°
TROPIC OF CANCER
10°
0°
10°
EQUATOR
80°
90°
100°
110°
120°

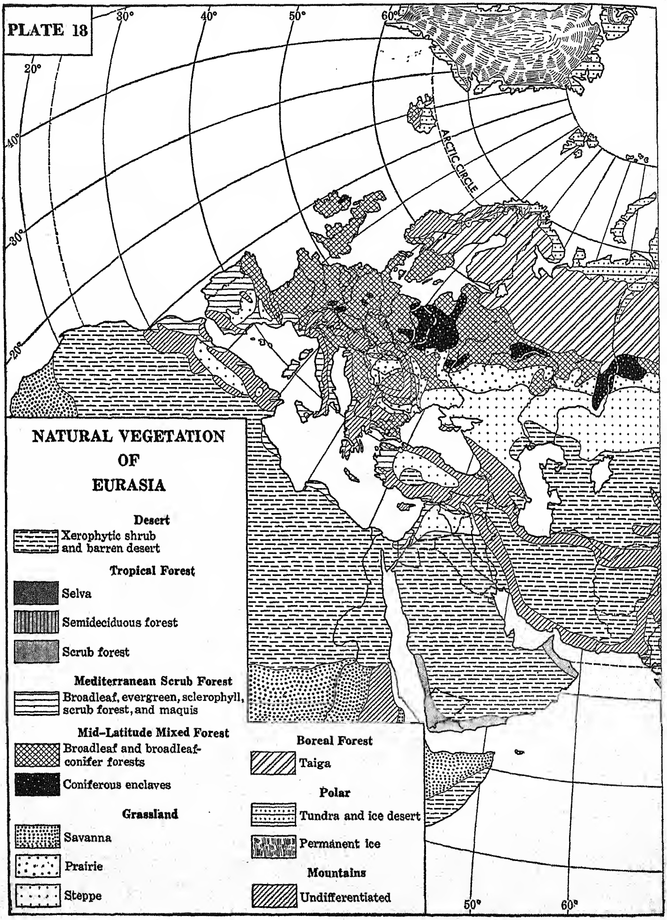


PLATE 18
NATURAL VEGETATION OF EURASIA
Desert
Xerophytic shrub and barren desert
Tropical Forest
Selva
Semideciduous forest
Scrub forest
Mediterranean Scrub Forest
Broadleaf, evergreen, sclerophyll, scrub forest, and maquis
Mid-Latitude Mixed Forest
Broadleaf and broadleaf-conifer forests
Coniferous enclaves
Grassland
Savanna
Prairie
Steppe
Boreal Forest
Taiga
Polar
Tundra and ice desert
Permanent ice
Mountains
Undifferentiated
ARCTIC CIRCLE
20°
30°
40°
50°
60°


80°
70°
60°
50°
40°
30°
20°
170°
180°
170°
160°
150°
10°
0°
10°
TROPIC OF CANCER
?
EQUATOR
80°
90°
100°
110°
120°

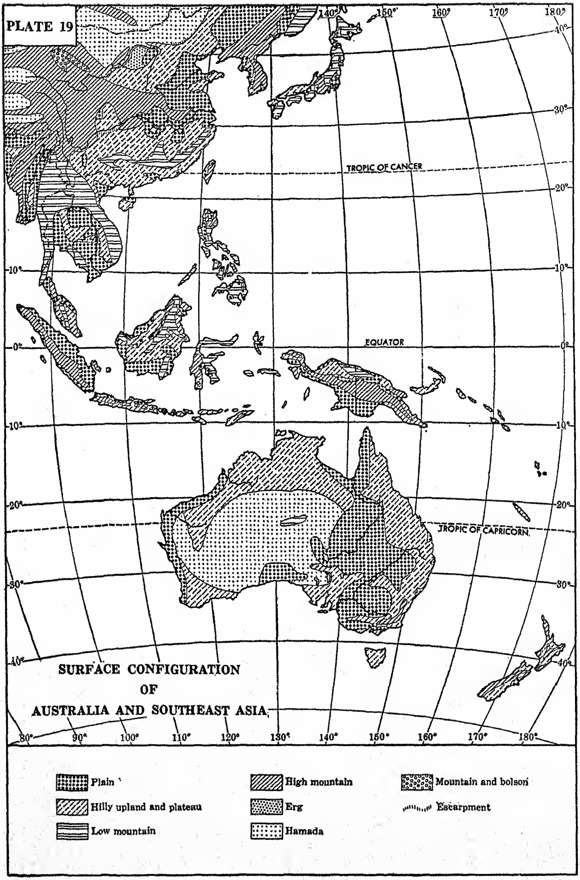


PLATE 19
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
SURFACE CONFIGURATION
OF
AUSTRALIA AND SOUTHEAST ASIA
Plain
Hilly upland and plateau
Low mountain
High mountain
Erg
Hamada
Mountain and bolson
Escarpment

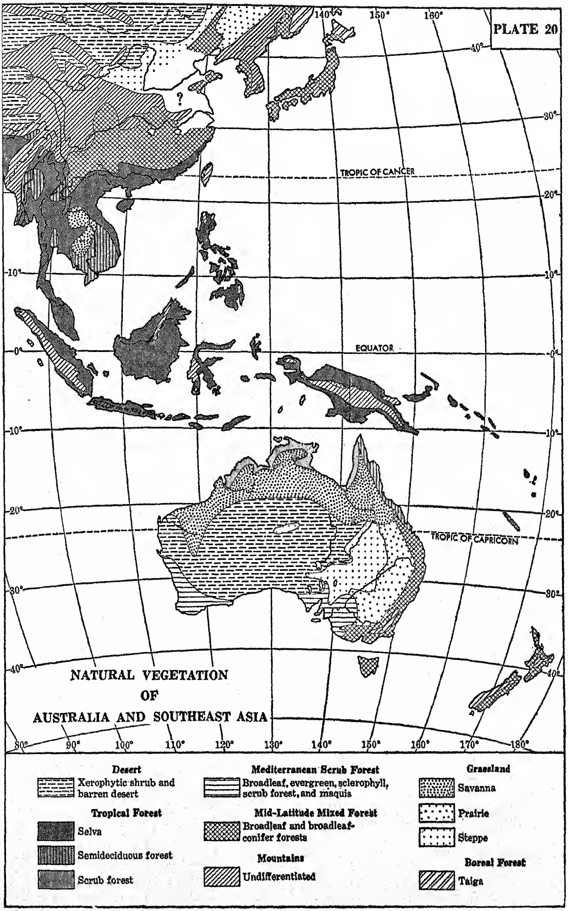


PLATE 20
NATURAL VEGETATION
OF
AUSTRALIA AND SOUTHEAST ASIA
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
40°
30°
20°
10°
0°
10°
20°
30°
40°
80°
90°
100°
110°
120°
130°
140°
150°
160°
170°
180°
?
Desert
Xerophytic shrub and barren desert
Tropical Forest
Selva
Semideciduous forest
Scrub forest
Mediterranean Scrub Forest
Broadleaf, evergreen, sclerophyll, scrub forest, and maquis
Mid-Latitude Mixed Forest
Broadleaf and broadleaf-conifer forests
Mountains
Undifferentiated
Grassland
Savanna
Prairie
Steppe
Boreal Forest
Taiga

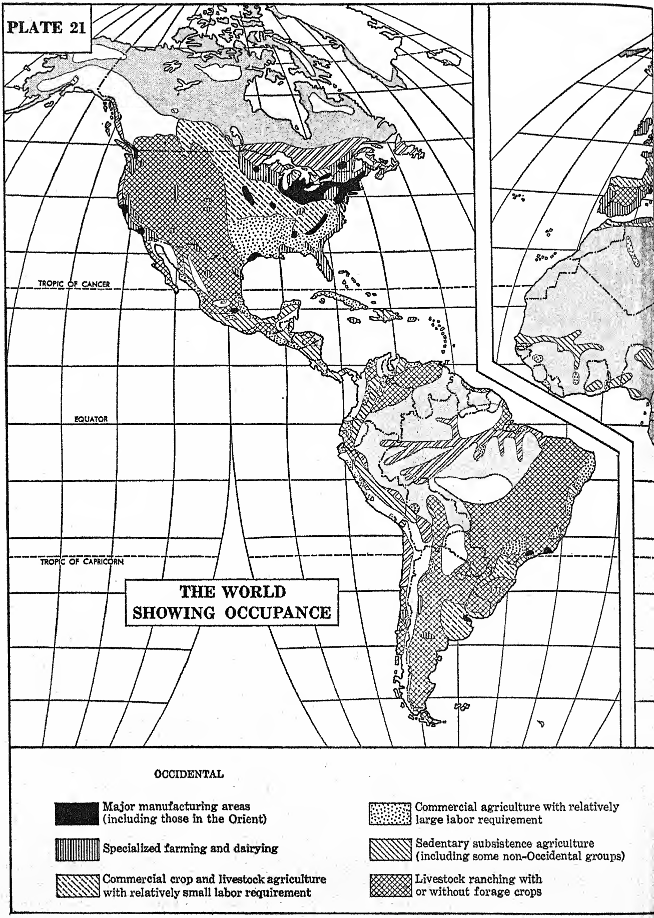


PLATE 21
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
THE WORLD
SHOWING OCCUPANCE
OCCIDENTAL
Major manufacturing areas
(including those in the Orient)
Specialized farming and dairying
Commercial crop and livestock agriculture
with relatively small labor requirement
Commercial agriculture with relatively
large labor requirement
Sedentary subsistence agriculture
(including some non-Occidental groups)
Livestock ranching with
or without forage crops

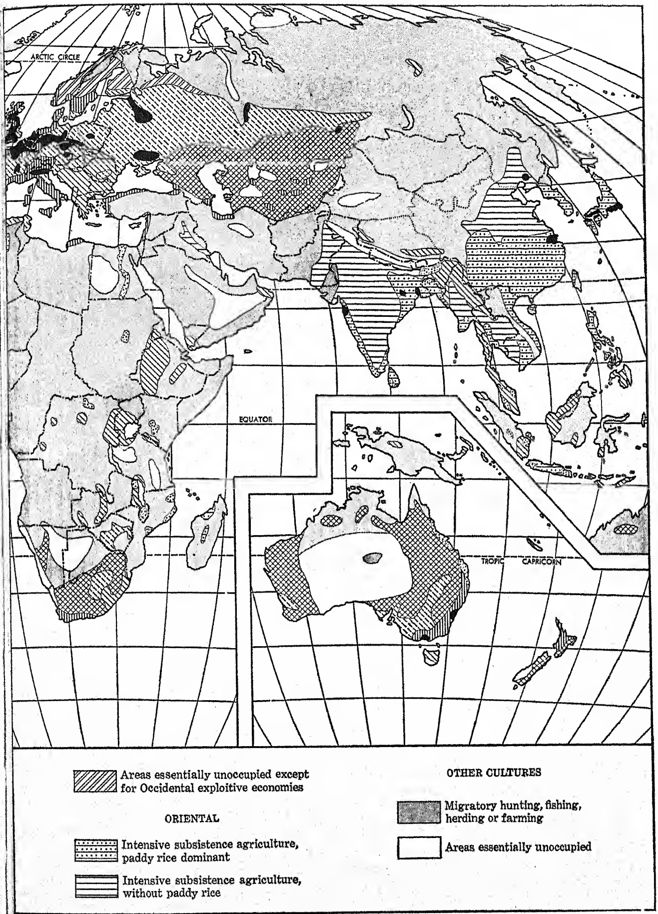
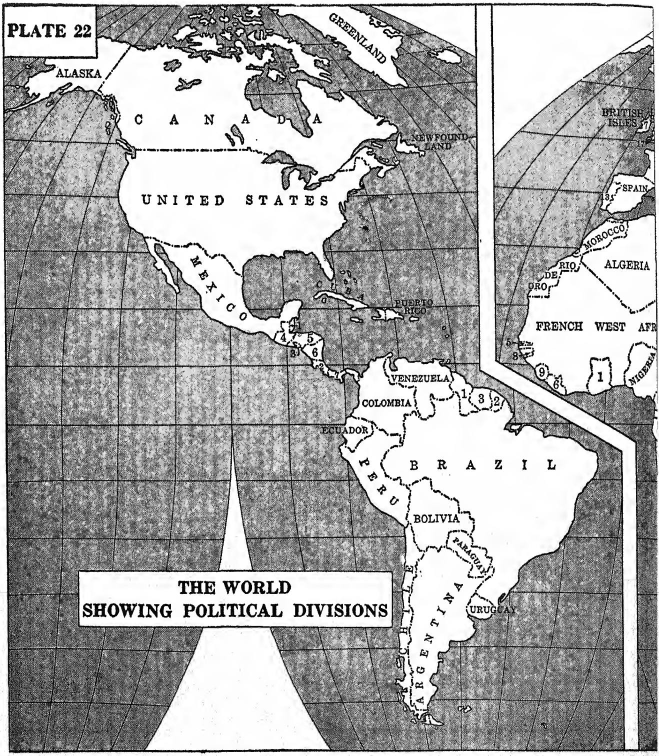

ARCTIC CIRCLE
EQUATOR
TROPIC CAPRICORN
Areas essentially unoccupied except for Occidental exploitive economies
ORIENTAL
Intensive subsistence agriculture, paddy rice dominant
Intensive subsistence agriculture, without paddy rice
OTHER CULTURES
Migratory hunting, fishing, herding or farming
Areas essentially unoccupied

PLATE 22



THE WORLD
SHOWING POLITICAL DIVISIONS

CENTRAL AMERICA

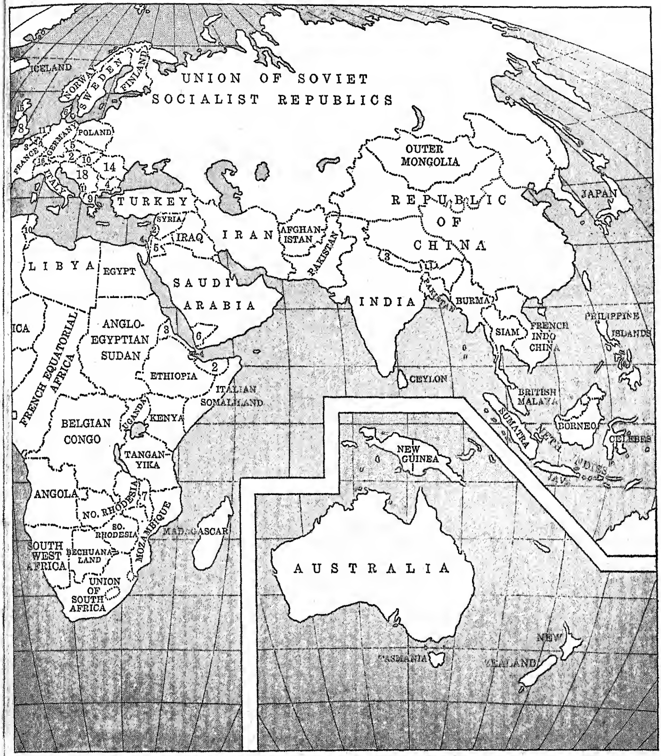
1-British Honduras
2-Costa Rica
3-El Salvador
4-Guatemala
5-Honduras
6-Nicaragua
7-Panama

SOUTH AMERICA

1-British Guiana
2-French Guiana
3-Surinam

AFRICA

1-Ashanti and Gold Coast
2-British Somaliland
3-Eritrea
4-French Somaliland
5-Gambia
6-Liberia
7-Nyasaland
8-Portuguese Guinea
9-Sierra Leone
10-Tunisia



ASIA

1-Bhutan
2-Lebanon
3-Nepal
4-Palestine
5-Trans-Jordan
6-Yemen

EUROPE

1-Albania
2-Austria
3-Belgium
4-Bulgaria
5-Czechoslovakia
6-Denmark
7-Eire
8-England
9-Greece
10-Hungary
11-Netherlands
12-Northern Ireland
13-Portugal
14-Rumania
15-Scotland
16-Switzerland
17-Wales
18-Yugoslavia

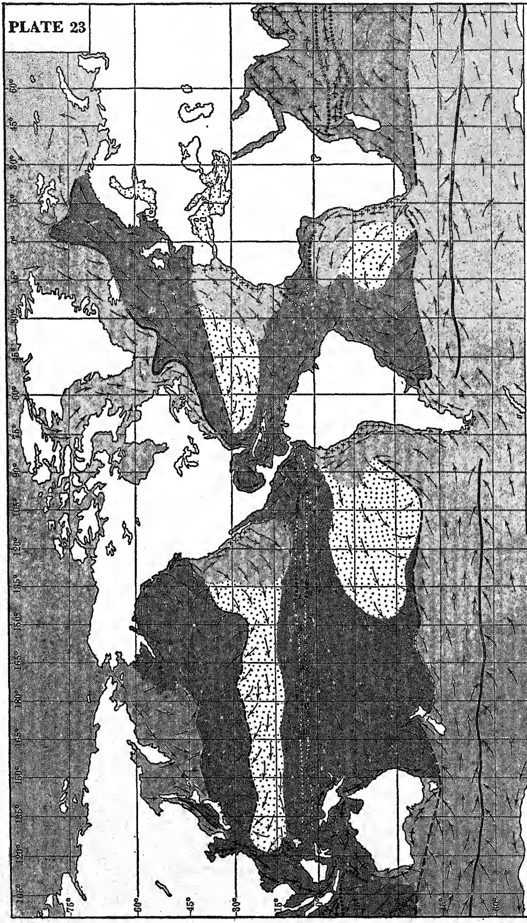
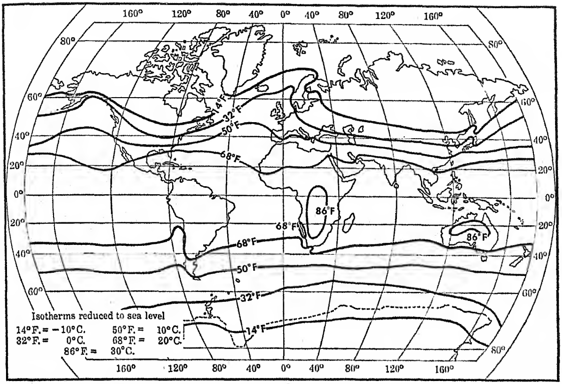
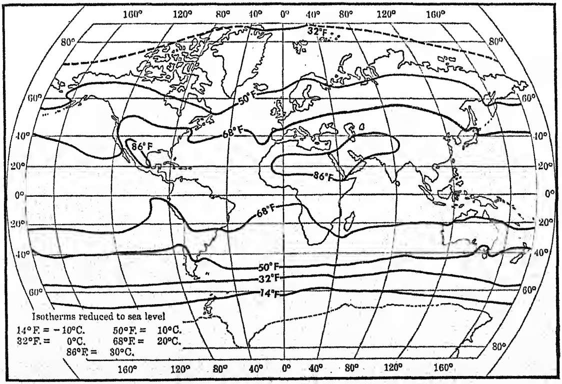


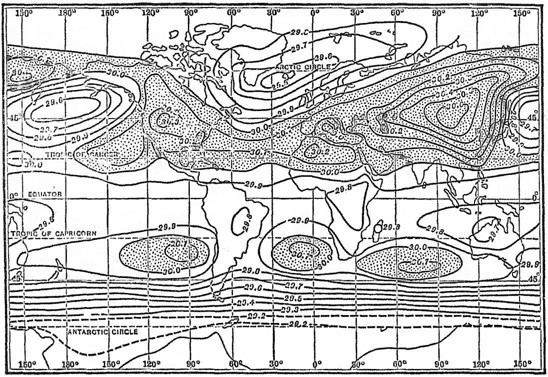
PLATE 23
OCEAN CURRENTS AND TEMPERATURES
After Gerhard Schott
WARM WATER
COLD WATER
WATER OF MODERATE TEMPERATURE
Ocean currents in northern winter
Currents which are reversed in northern summer
Upwelling cold water
Polar convergence
Subtropical convergence
Equatorial countercurrent



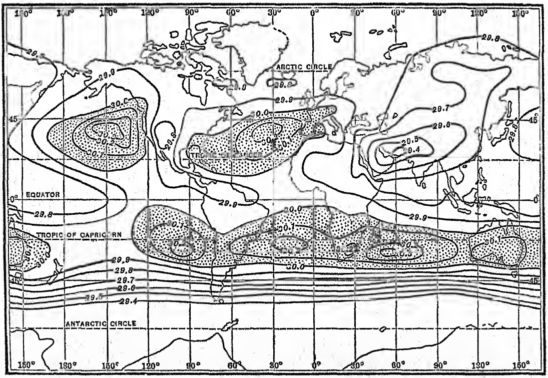
(a) *Average temperatures in January.* (After Gerhard Schott)



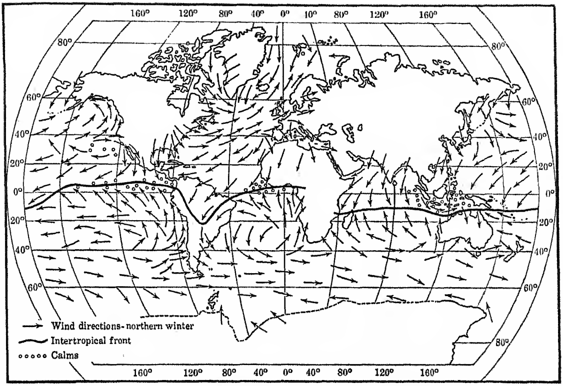
(b) *Average temperatures in July.* (After Gerhard Schott)



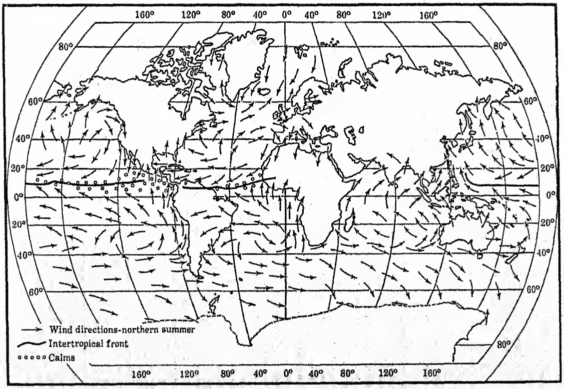
(a) *Mean pressure for January.* (After Kendrew)



(b) *Mean pressure for July.* (After Kendrew)

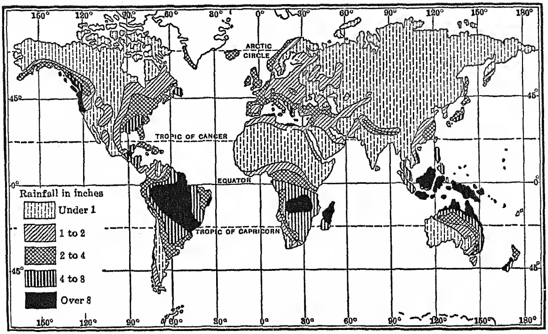


(a) *Average wind direction in January.* (After Gerhard Schott)

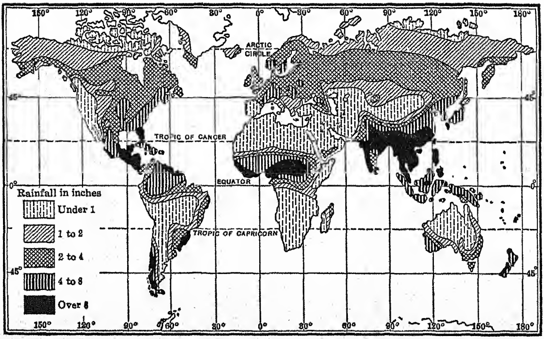


(b) *Average wind direction in July.* (After Gerhard Schott)

PLATE 27



(a) *Mean rainfall for January.* (After Kendrew)



(b) *Mean rainfall for July.* (After Kendrew)

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NOTE. Map pages and plates are in boldface type; picture pages are in italic.

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